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U. S. NAVAL ACADEMY, ANNAPOLIS,

October 9, 1878.

Commander W. T. Sampson, U. S. N., in the Chair.

## NOTES ON NITRO-GLYCERINE.

By Prof. Charles E. Munroe, U. S. N. A.

The manufacture of nitro-glycerine is based upon the reaction which takes place when glycerine is brought in contact with nitric acid and which may be represented by

$$C_3H_5O_3H_3+3HONO_2=C_3H_5(NO_2)_3O_3+3H_2O$$

in which one molecule of glycerine being acted upon by three molecules of nitric acid yields one molecule of tri-nitro-glycerine and three molecules of water. Three of the atoms of hydrogen in the glycerine being replaced by the three atoms of nitryl ($NO_2$). in the three molecules of nitric acid.

It is believed to be possible to produce three different nitro-glycerines. By replacing one atom of hydrogen in the glycerine by one atom of nitryl the mono-nitro-glycerine is formed, having the formula $C_3H_5NO_2$ $H_2O_3$. By replacing two of the atoms of hydrogen by two of nitryl the di-nitro-glycerine is produced, having the formula $C_3H_5(NO_2)HO_3$. By replacing the three atoms, we get the tri-nitro-glycerine given in the reaction above.

It is believed also that the tri-nitro-glycerine is the only one of these compounds which is stable and that many of the accidents which have been caused by nitro- glycerine have been due to the presence of these other compounds in the tri-nitro-glycerine.

To produce pure nitro-glycerine it is necessary that we should use the purest, most concentrated glycerine and the purest, strongest nitric acid. The presence of any fatty impurities in the glycerine gives rise to the decomposition and spontaneous explosion of the nitro glycerine,

hence the necessity of purity. It is difficult to obtain anhydrous glycerine and anhydrous nitric acid, hence it is the custom to use the most concentrated articles to be obtained and to mix with them some substance which will absorb the water and thus render them anhydrous. The importance of using an exsiccating substance is further shown, if we refer to the reaction, by the fact that water is one of the products of the reaction and hence if we were to start with anhydrous glycerine and nitric acid, after a portion of the glycerine has been converted the water formed will have so diluted the remainder that there is danger of the lower nitro-substitution products being formed.

Concentrated sulphuric acid is used as the exsiccating substance and it is added in sufficient quantity to combine not only with the water contained in the original substances but also with all the water formed during the operation. But in using the sulphuric acid another element of danger is introduced. The sulphuric acid removes the water by entering into chemical combination with it, a hydrate of sulphuric acid being formed, and this combination is attended with the development of heat. If the temperature is raised somewhat there is danger of the nitro-glycerine being exploded or if an explosion does not result the glycerine will be wasted by being converted into oxalic acid and other products, which may render the nitro-glycerine unstable. Hence it is necessary to keep the mixture cool while the conversion is taking place and in the process of manufacture this is effected by means to be described.

I have thus attempted to state as briefly as possible the rationale of the operations in the manufacture of nitro-glycerine. I will now describe some of the processes employed.

Sobrero, the discoverer of nitro-glycerine, proposed the following process for its manufacture ; one half oz. of anhydrous glycerine is poured with constant stirring into a mixture of two ozs. of concentrated sulphuric acid and one oz. of fuming nitric acid of Sp. Gr. 1.52, the temperature of the mixture being kept below 25°C. by external cooling with ice, and as the oily drops begin to form on the surface, the mixture is poured with constant stirring into fifty ozs. of cold water. Nitro-glycerine then separates and may be purified by washing and drying in small portions, in a vapor bath. (Liebe, Arch. Pham. ciii, 158 ; civ, 282.)

De Vrij's process differs from the above only in the proportion of the acid used and in the fact that the sulphuric acid was added after the mixture of the glycerine with the nitric acid had been effected.

The Mowbray process as used at North Adams and in a much im-

proved form at Newport, is simply an adaptation of the Sobrero process to the commercial manufacture.

Many of you are familiar with the process, yet you will pardon me if I call your attention to it again in order to compare it with the processes which are afterwards to be described. The acids are first mixed in the proportions of one part of nitric acid (Sp. Gr. 1.45) to two pts. of sulphuric acid (Sp. Gr. 1.8) and cooled.* The operation is conducted, in the words of Prof. Hill, as follows.

"The apparatus used for this purpose, at the Station, is shown on the Plate. An elevation, section and plan are given, the lettering being the same in the three.

A, A, A, A, A, A, are wooden troughs placed around the brick chimney D, D. In these troughs are the earthen-ware pitchers a, a, a - - - a which contain the acid mixture. On the shelf B, above the pitchers, are the bottles b, b, b, - - - - - b which contain the glycerine. The bottles are loosely closed by wooden stoppers with broad, rounded tops. Through holes in these stoppers, pass loosely the rubber tubes c, c, c, c, which reach to the bottom of the bottles and carry small glass jets at their outer ends. Conical wooden plugs e, e, e, e, are placed in the holes through the stoppers, alongside the rubber tubes.

The steam pipe G passes along the shelves B, B, just behind the glycerine bottles. The air-main F passes under the shelf B, and carries on its under side a number of small short pipes or jets, (two for each pitcher,) to which are attached the rubber tubes d, d, d, d, which hang over the pitchers. In these rubber tubes are inserted glass tubes, long enough to extend to the bottom of the acid pitchers. In the elevation, these tubes are out of the pitchers, but in the section they are in place as if in use.

The troughs are made tight to hold the ice water with which the pitchers are surrounded. Partitions, with openings at the bottoms, cut off the corners of the troughs, forming clear spaces f, f, f, f. These spaces contain water only, as the partitions keep out the ice. These water spaces are convenient as affording opportunities for quickly emptying a pitcher into water if it becomes necessary. In one corner of each trough is placed a pipe, through which the water may be drawn off into the escape E, when the operation is finished.

The pitchers stand on narrow strips, which raise them off the bottom about two inches, thus giving the cold water free access all about

* Notes on Explosives, by Walter N. Hill, S. B., Chemist U. S. Torpedo Station.

them, and when in position are well under the overhanging hoods $C_1$,$C_2$. These hoods are flat wooden boxes, wide at the bottoms and drawn in at the tops, where they fit against openings in the chimney D, D. In the lower part of the chimney, on the floor below, is placed a grate and fire door (not shown in drawing).

Each pitcher receives 18 to 20 pounds of the acid mixture (according to the strength of the latter). All are then set in place in the troughs, covered with glass plates, surrounded with ice and water and allowed to stand until completely cooled. Into each bottle is put two pounds of glycerine.

When the acid in the pitcher has fallen to the temperature of the surrounding ice water, the covers are removed from the pitchers and the air tubes passed through holes in the hoods down into them. Through these air-tubes a strong current of air is forced by means of a pump driven by steam. This current of air keeps the contents of the pitchers in continual agitation. The air for the pump is drawn through sulphuric acid to render it perfectly dry, and just before it enters the air-main over the troughs, it is thoroughly cooled. The cooling arrangement is made of ten coils of small tin pipe, which are surrounded by ice, (or better, ice and salt). These coils are so arranged as to give an extensive cooling surface without impeding the current.

As soon as the air-current has been turned on, the flow of the glycerine is begun. Each rubber tube c is a siphon, which is started by suction through a glass tube inserted in the outer end. As soon as the glycerine runs freely, the suction tube is withdrawn, and a fine pointed glass jet put in its place. The glycerine runs from this jet in a fine stream directly into the pitcher under it. In cold weather the glycerine may become too thick to flow easily. To overcome this, the bottles of glycerine are warmed by passing steam through the pipe behind them until the glycerine is sufficiently thin.

The glycerine dropping into the acid mixture is rapidly acted on and converted into nitro-glycerine."

When the whole of the glycerine has run into the acid mixture, the mixture of acids and nitro-glycerine are poured into a large wooden tub filled with water and the nitro-glycerine is washed until all traces of the acids are removed.

## Nobel's Process.

In *Nobel's process a large leaden cylinder capable of holding 200

* From a verbal description by M. Alphonse Brunet, Ingénieur du Syndicat des Fabriques de Dynamite.

litres is placed inside a wooden cylinder. Cold water circulates in the space between the two, and also, through a leaden worm coiled up in the inside of the leaden cylinder. The charge of acid is placed in the converter, and a leaden pipe with a perforated nozzle introduces the glycerine into the center of the acids. Inside of this pipe is another which brings in the compressed air so that the glycerine is forced into the acid mixture under a considerable pressure and the mixing is very intimate and rapidly effected.

The acid mixture is obtained by dissolving one part of $KNO_3$ in three and a half parts of $H_2SO_4$ of Sp. Gr. 1.8. The mixture is cooled down to 0° C. when the whole of the potash separates out as $K_2SO_4$ after the reaction.

$$H_2SO_4+2KNO_3=K_2SO_4+2HNO_3$$

and there remains a mixture of the strongest nitric and sulphuric acids

After the conversion of the glycerine is complete, it is run into the washing tanks and finally treated with three per cent. of $Na_2CO_3$.

By this apparatus one thousand kilos. of nitro-glycerine are made per day at Paulille, in Southern France.

* In 1876 the Noble process was used, with some slight modifications, at 14 factories.

| Date of foundation. | | |
|---|---|---|
| 1865. | Vinterudken, near Stockholm, | Sweden. |
| 1866. | Christiana, | Norway. |
| 1865. | Krümmel, near Hamburg, | Germany. |
| 1868. | Zamky, near Prague, | Austria. |
| 1872. | Schlebuch, near Cologne, | Germany. |
| 1874. | Presburg, | Hungary. |
| 1872–3. | Isleten, canton of Uri, | Switzerland. |
| 1872–3. | Avigliana, near Turin, | Italy. |
| 1872. | Galdacano, near Bilbao, | Spain. |
| 1873–4. | Trafaria, near Lisbon, | Portugal. |
| 1871. | Ardeer, near Glasgow, | Scotland. |
| 1870-71. | Paulille, near Port-Vendres, | France. |
| 1868. | San Francisco, | |
| 1873. | New York. | |

Since then, the Scottish works have been removed to Stevenson. These factories produced in 1874, three and a half million kilogrammes of dynamite. The most important factory is that of Krümmel, where

* Les Explosifs Modernes par Nobel, Roux et Sarrau, page 161.

the product is six hundred thousand kilogrammes. The factories at Zamky, Stevenson and San Francisco, follow with an annual yield of from four hundred thousand to five hundred thousand kilos.

At Stevenson, the nitric acid is made by the ordinary process, which consists in heating potassic or sodic nitrate in large retorts with sulphuric acid, and condensing the nitric acid, which is given off; or else it is absorbed by concentrated sulphuric acid and the mixture used for making nitro-glycerine.

At this factory the mixture of nitro-glycerine and mixed acids is run off from the convertor into settling tanks and when the nitro-glycerine has settled, the acids are drawn off and used for making nitric acid.* The nitro-glycerine is then run into the washing tank and washed as usual.

I am indebted to Mr. Alex. Cuthbert the manager of the Stevenson works, for a copy of the tests which are applied to the glycerine used by them; and also, for a copy of the Government test for nitro-glycerine mixtures.

### Essentials of Glycerine Used by Nobel's Explosive Company, Glasgow.

"For our own purpose glycerine, when diluted with twice its bulk of pure water, should give no precipitate with ammonia, even after standing for some time. There should be no precipitate with ammonia and oxalate of ammonia, Nitrate of silver added to it ought not to make it milky. Hypo-nitric acid passed through it ought not to curdle it. The smell, if there is any at all, ought not to be unpleasant nor the color dark.

Complete solubility in water shows freedom, in some degree, from oil or fat. Precipitates with ammonia, show iron and alumina; with oxalate of ammonia, lime; with nitrate of silver, chlorides: curdling with hyponitric acid shows presence of fatty acids (oleic, margaric and palmitic), all of which are objectionable, and shows imperfect decomposition of the fat or oil from which the glycerine has been made, and also, defective distillation. A bad smell indicates decomposition in the still, and a dark color indicates charring. Both of these are caused either by too little steam in the still, or by too high a temperature in it. The distillation to be good must be effected in an atmosphere of super-heated steam at a temperature of 500° to 600° Fah., rather less than more. But the concentration of the distilled glycer-

* From a verbal statement by Mr. Cuthbert.

ine must be effected in so called vacuum pans, in the same way that sugar liquors are concentrated. Any over heating during this operation is sure to cause decomposition that will injuriously affect the yield of nitro-glycerine."

HEAT TEST FOR NITRO-GLYCERINE MIXTURES.

"Experiments to ascertain whether a heat-test, similar to that adopted in the case of gun-cotton, could be applied to nitro-glycerine preparations of different kinds for the purpose of exercising control over the quality, in regard to stability, of commercial preparations of this class.

These experiments were carried on in the Chemical Establishment of the War Department, and embraced a trial of a large number of specimens, including samples that from time to time had been forwarded to the Committee for examination, and trade samples received from H. M. Inspector of Magazines.

The method of applying the test and the results obtained, are given in the following Memorandum from the War Department Chemist.

WOOLWICH, February 11th, 1874.

Secretary of Special Committee on Gun Cotton, &c.:

In accordance with the request of the Committee I have instituted a series of experiments with the view of ascertaining whether a heat-test, similar to that employed as a means of ascertaining whether the processes of purification have been sufficiently applied to gun-cotton, can be applied to uitro-glycerine preparations of different kinds, for the purpose of exercising control over the quality, in regard to stability, of commercial preparations of this class.

As these preparations differ considerably from each other, both as regards the proportion of nitro-glycerine which they contain and as relates to the solid materials with which that substance is mixed, the most satisfactory course to be pursued in applying a heat-test for comparative purposes would at first sight appear to consist in extracting the nitro-glycerine itself from the preparation to be tested and applying the heat-test to the liquid, apart from the other ingredients of the preparation. I therefore instituted a number of experiments in this direction, but with unsatisfactory results. Mechanical means were found to be inapplicable to the separation from small samples (say one cartridge) of even those materials richest in nitro-glycerine sufficient of the liquid for purposes of testing; its extraction by means of a solvent was also found to be inexpedient, because the obstinate retention by the nitro-glycerine of small portions of the solvent used, was found likely to become a fruitful source of fallacious results. It was ascer-

tained, moreover, that the period for which nitro-glycerine may be exposed to heat (150–160° F.) before it furnishes any indication of change by the disengagement of acid vapor; is very different when the liquid is heated by itself and when it is reduced to a state of division by absorption in some porous medium or by mixture with solid substances of inert character.

I therefore proceeded to apply to various samples of dynamite and other nitro-glycerine preparations, in their original condition, the heat-test described in detail in the official specification which governs the supply of compressed gun-cotton to H. M. Government.

An entire cartridge or half a cartridge of each sample (previously thawed, if frozen,) was rubbed up thoroughly, so as to furnish a uniform sample as pulverulent as it could be obtained. Fifty grains were then introduced into the test tube, pressed down firmly by means of a flat-headed glass rod, and placed in the testing bath which was maintained at 160° F., the test being carried out in accordance with the directions laid down in the gun-cotton heat test.

The following results were obtained with samples which I have here distinguished by numbers,* giving at the same time the percentage of nitro-glycerine in such as it had been estimated in.

| Number of sample. | Percent'ge of nitro glycerine. | Duration of exposure to 160° F. before the test pap'r was affected | | REMARKS. |
|---|---|---|---|---|
| | | Duplicate experiments. | | |
| | | min. | min. | |
| 1 | 73–75 | 5¼ | 5¼ | |
| 2 | | 2½ | 3 | |
| 3 | | 8 | 8 | |
| 4 | | 9¾ | 8½ | |
| 5 | 59.5 | 2 | 1¾ | This sample reddened blue Litmus paper readily at ordinary temperature. |
| 6 | 66.7 | 1½ | 1¼ | |
| 7 | 18 | 12 | 10¾ | |
| 8 | 20 | 29 | 28 | This sample contained 0.47 per cent. of paraffin. |
| 9 | 73–75 | 6½ | 6½ | |
| 10 | | 6½ | 5½ | |
| 11 | | 6¼ | 6¼ | |
| 12 | 73 | 1¾ | 1¼ | This sample reddened Litmus paper slightly. |
| 13 | 52 | 22 | 21 | This sample contained a number of small lumps of carbonate of soda. |
| 14 | 59–60 | 1 | 1 | |
| 15 | | 1 | 1 | These samples reddened Litmus paper at ordinary temperature. |
| 16 | 73–75 | 5 | 4¾ | |
| 17 | | 5 | 5 | |
| 18 | | 4¾ | 5 | |
| 19 | | 12¼ | 13 | |

* The whole of these samples have been sent to me for the purposes of these experiments, either by the Committee or by Major Majendie, R. A. H. M. Inspector of Magazines.

It was thought possible, before this series of experiments was carried out, that the proportion of nitro-glycerine, in a given sample, might considerably influence the results obtained, but it appears to be satisfactorily indicated by the comparative results furnished with samples 2, 4, 5 and 7 (as well as with others) that such is not the case at any rate to an extent to affect the value of the test as a comparative one.

The high results furnished by sample 13, were unquestionably to be ascribed to the presence of a large proportion of a substance (carbonate of soda) capable of neutralizing any acid liberated by the action of heat, and it is probable that some other high results observed in the series are ascribable to the same cause, as an alkaline (or earthy) carbonate is at any rate occasionally used as a protective constituent in the production of this class of preparations. There is no question that the keeping properties of a nitro-glycerine preparation are, at least in many cases, likely to be considerably improved by such a precautionary measure. The fact that the existence of such an ingredient as carbonate of soda, in a particular sample, has the effect of raising the test which would be furnished by that sample if the neutralizing material were not present, can therefore not, in my opinion, be considered to reduce the reliability of the test as a practical indication of the stability of the preparations examined.

There appear to be strong grounds for ascribing the high results furnished by No. 8 sample to a protective action exerted by the paraffin which existed in that particular preparation. I am, however, unable to speak with decision on this point, which could only be satisfactorily determined by experimenting with preparations made up of one and the same batch of nitro-glycerine, with and without the addition of paraffin, but in all other respects alike.

Some considerable experience in the application of the heat-test to samples of the various nitro-glycerine preparations of commerce is indispensable before a decided opinion can be given as to the minimum duration of exposure to 160° F., which a sample should sustain before any reaction is produced upon the test paper. The results obtained with samples 1, 3, 9, 10, 11, 16, 17 and 18 (of which there was not one possessing exceptional characters) appear, however, to indicate that samples of dynamite, &c., should sustain exposure to 160° F. (in the manner specified) for not less than 5 to 6 minutes before producing any action upon the test paper.

(Signed) F. A. ABEL.

FIG. 4

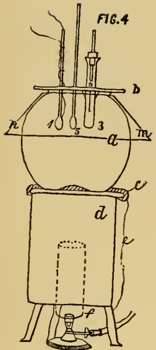


FIG. 5

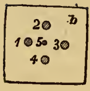


FIG. 8

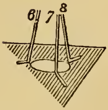


FIG. 7

Apparatus required.—1. A spherical glass vessel, Fig. 4, about 8 inches diameter (a) filled with water to within a quarter of an inch of the edge, having a loose cover of sheet tin or copper about 7 inches square (b), rests on a tripod stand about 14 inches high (c), covered with coarse iron-wire gauze (e), and surrounded with a screen of thin sheet copper (d). Within this is placed an argand burner (f) with glass chimney. Over the glass globe is placed a common green paper lamp shade (mn). The cover (b) has 5 holes arranged as seen in Fig. 5; No. 5 to receive the thermometer; No. 1, the regulator; No. 4, a small funnel; and Nos. 2 and 3, test tubes containing the gun-cotton to be tested. Around holes 2 and 3 on the under side of the cover are soldered 3 pieces of brass wire with points slightly converging (Fig. 6 turned upside down), these, acting as springs, allow the test tubes to be easily placed in position and removed.

2. Scheibler's temperature regulator.
3. Two cells of Le Clanché's battery, No. 1.
4. A few yards of insulated copper wire.
5. Test tubes about $\frac{5}{8}$ inch diameter and not less than 5 inches long.
6. Glass rod with a flat head, of sufficient length to reach to the bottom of the test tubes.
7. Corks, fitting the test tubes and carrying an arrangement for holding the test paper (a thin glass tube passing through the centre of the cork, drawn out and terminating in a platinum wire hook, Fig. 7).
8. A thermometer with range not less than 30° to 212° Fahrenheit.
9. A minute clock.

Materials required.—The test paper is prepared as follows:—45 grains of white starch are added to $8\frac{1}{2}$ ounces of water, and the mixture is stirred and heated to boiling; 15 grains of iodide of potassium are dissolved in $8\frac{1}{2}$ ounces of water. The two solutions are thoroughly mixed together. Strips or sheets of white Swedish filter paper are

dipped in the solution thus prepared; they are then allowed to drain and dry. The dimensions of the pieces of test paper used, are about ½ inch by ⅝ inch. The paper should be preserved in a well-stoppered or corked bottle.

Preparation of Samples for Testing.—Half a cartridge of the material (or about 500 grains, if it is not supplied in the form of cartridges,) is thoroughly rubbed up together so as to furnish a very uniform sample. If the material is frozen, it should first be thawed.

Application of the Test.—The thermometer is fixed so as to be inserted through the lid of the glass globe into the water (which is to be steadily maintained at a temperature of 160° Fahrenheit) to a depth of 2¾ inches. 50 grains of the sample to be tested, are inserted into the test tube and gently pressed down to the bottom, with a flat headed glass rod. The test tube is then inserted through the perforation in the cover and is immersed in the hot water to the depth of 2½ inches, the tube being closed with a loosely fitting cork. A test paper is fixed on the lower extremity of the glass rod, so that, when inserted into the tube, it will be in a vertical position. A drop of distilled water containing 10 per cent. of pure glycerine is applied to the upper edge of the test paper, the quantity used being only sufficient to moisten about half of the paper; the first cork is then taken out of the test tube and replaced by the cork holding the glass rod and test paper, keeping the test paper as near the top of the test tube as possible· until the tube has been immersed for about 5 or 6 minutes. A ring of moisture will, about this time, be deposited in the test tube a little above the cover of the bath; the glass rod must then be lowered until the lower margin of the moistened part of the paper is on a level with the bottom of the ring of moisture in the tube; the paper is now closely watched. The test is complete when a very faint brown coloration makes its appearance at the line of boundary between the dry and moist part of the paper. The interval of time between the first insertion of the tube containing the sample in the water at 160° and the first appearance of discoloration on the paper, constitutes the test."

### Works at Vonges.*

The manufacture of nitro-glycerine is carried on by the French government at the powder mills at Vonges, in the eastern part of the

* The works at Vonges were not in operation during my visit and I could only see the plant, I am indebted to my courteous and obliging escort M. Georges Coutagne, Ingênieur des Poudres et Salpêtres, for the description of its mode of use.

country, about thirty miles from Dijon. The factory consists of six light frame buildings about thirty feet long, fifteen feet high, well lighted by six windows on the front which extend nearly to the ground The buildings stand along the side of a stream with earth embankments behind each building and earth traverses between the buildings. The buildings are used as follows.

No. 1. For mixing the acids.
" 2. " " " glycerine and sulphuric acid.
" 3. For making dynamite.
" 4. For washing the nitro-glycerine.
" 5. For making nitro glycerine.
" 6. " " " "

Besides these there is an old shed near No. 1 where the mixtures are cooled.

In No. 1 the nitric and sulphuric acids are mixed in equal proportions by weight.

The apparatus used consists of a semi-cylindrical trough, Fig. 8., of iron lined with lead, about 1 metre long and 40 cm. in diameter. The trough is surrounded by an iron jacket. Water is kept circulating in the space between in order to keep the mixture cool. When the apparatus is in use it is covered with a semi-cylindrical iron cover, lined with lead, to prevent loss by spattering. A shaft running the length of the trough and turned from the outside by a crank, is armed with paddles which, when the shaft is turned, mix the acids together very intimately. A leaden tube at the bottom allows the acid to run off into carboys. The apparatus rests on a light iron frame.

The acids are now carried in the carboys to the cooling shed where they are immersed up to their necks in troughs of cold water and allowed to remain till thoroughly cooled. The cooling shed is open on all sides to admit of the ready circulation of the air but covered on top to shield the acids from the influence of the sun.

In the next building the glycerine is mixed with concentrated sulphuric acid, by means of a similar apparatus to the one described above, in the proportion of one hundred kilos of the glycerine to three hundred and twenty kilos of the acid. This mixture stored in carboys is then removed to the cooling shed.

We will now turn to the converting rooms. Here the earthern pots Fig. 9. used for the conversion of the glycerine, twenty in number, are ranged in two rows elevated on a platform about a metre high, with about a metre space between the rows. The pots are of about eighty

three litres in capacity. They are closed with leaden covers sealed with sulphuric acid to prevent the exposure of the entire surface of the mixture to the atmosphere, for this would permit the absorption of the aqueous vapor in the atmosphere which would result in the dilution of the acid and endanger the safety of the process or at least render the yield less. As however during the operation fumes may be generated which will exert pressure, a vent Fig. 10 must be provided. This is secured by fitting into the cover two pieces of lead pipe 4 cm. in diameter and 5 cm. long. Around each of these outlets another piece of pipe 6 cm. wide and 4 cm. long, is fastened to the outside of the lid, thus making an annular space which may be filled with strong sulphuric acid to act as a seal. A leaden cap fits over the inner tube and a curved leaden tube about ½ cm. in diameter leads from the top of the cap, and permits the nitrous fumes to escape into the air.

The object of this apparently complicated device is as follows. When the action is going on quietly the small tubes are of sufficiently large dimensions to permit the gases generated to escape freely but if through any cause a large volume of gas is generated the pressure will cause the caps to be lifted and the entire area of the 4 cm. pipe will then be exposed, thus furnishing, without any harm being done, a sufficiently large opening for the escape of the gas.

The remainder of the apparatus consists of a bent lever for raising the covers of the pots which lets into two upright iron bars which are erected beside each pot, and of lead siphons for running off the acids and nitro-glycerine.

To make the nitro-glycerine forty-two kilos of the mixture of glycerine and sulphuric acid and fifty-six kilos of the mixed acids are poured into the pot, both of the mixtures having been thoroughly cooled. The cover is then put on, and the action is left to go on over night.

You will please observe how unlike this process is to any other suggested. Here the mixture is surrounded by the atmosphere solely, whereas, in all other processes, the mixture is kept cool by being surrounded with ice or with cold water. In other processes the mixture is continually agitated by a current of air or by some mechanical means while here the materials are allowed to mix quietly together. And finally while in the other processes the glycerine is added in small quantities to the acids and the process has to be closely watched to prevent accidents, here the whole of the glycerine is added at once to the acids and the operation is left to itself. Yet this operation seems to be with-

out danger for not a single accident has occurred since 1871, when the manufacture was begun at this place by this method. Besides the freedom from danger this process gives a larger yield of nitro-glycerine than any other and the product is very pure.

The comparative yield is shown in the following table.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Champion and Pellet's process | 1 kilo. | of gly. | yields | 1.2 to 1.3 | kilo. | of n. gly |
| Girard, Millot and Vogt's " | 1 " | " | " | 1.3 | " | " |
| Mowbray's process at Newport, | 1 " | " | " | 1.6 " 1.5 | " | " |
| Process at Vonges | 1 " | " | " | 1.8 | " | " |
| Theoretical yield | 1 " | " | " | 2.46 | " | " |

Hill obtained by the action of the strongest nitric acid on anhydrous glycerine 1.96, 1.89 and 2.03 parts of nitro-glycerine from 1 of glycerine. De Vrij obtained by the same process 1.84 parts of nitro-glycerine.

The following table shows the relative amounts of acid used in various processes.

| | Nitric. | Sulphuric. | Glycerine. |
|---|---|---|---|
| De Vrij | 200 pts. | 200 pts. | 100 pts. |
| [1] Sobrero | 200 " | 400 " | 100 " |
| [1] Siebe | 200 " | 400 " | 100 " |
| [1] Champion | 226 " | 426 " | 100 " |
| [1] Paeger & Betram | 266 " | 533 " | 100 " |
| [2] Hill | 300 " | 600 " | 100 " |
| [1] Vongés | 280 " | 600 " | 100 " |
| Theory requires | 206 " | | 100 " |

After the operation of converting the glycerine is completed, the mixture is siphoned off and conveyed in earthern vessels to the washing room where it is thrown into water to remove the acid, the last traces of the acids being neutralized by carbonate of magnesia. It is then allowed to settle and is stored in the magazine.

When used for making dynamite it is conveyed to the dynamite building. Here the infusorial silica, previously dried and sifted, is spread out on a low wooden table covered with lead. The nitro-glycerine is poured upon it, and then a workman with a rolling pin incorporates the mass thoroughly. After the whole is incorporated the dynamite is squeezed in a large, wooden cylindrical vessel, having a perforated bottom, and provided with a plunger by which any excess of nitro-glycerine is squeezed out. The vessel is suspended vertically

1. From M. Coutagne's note book.
2. Calculated from amount of acids used given on pg. 8.

upon trunions so that it may be readily overturned and emptied. The dynamite is now ready for cartridges. Three kinds of dynamite are made at Vonges.

| | | | | | | |
|---|---|---|---|---|---|---|
| No. 1 | contains | 75 | per cent. | of | nitro-glycerine. | |
| " 2 | " | 50 | " | " | " | " |
| " 3 | " | 30 | " | " | " | " |

Two to three per cent. of carbonate of magnesia are added to the dynamite as a precautionary measure to neutralize any traces of acid remaining in the nitro-glycerine.

## DISCUSSION ON THE PAPER.

Lieutenant Soley. I noticed that the lecturer stated that the nitro-glycerine was tested with oxalate of ammonia for lime. It seems to me that the use of so much water would involve the presence of considerable lime in the explosive. Would the lime be deleterious, as in gun cotton?

Professor Munroe. The test for lime was made in the glycerine before its conversion into nitro-glycerine. It is necessary that the glycerine should be absolutely pure. Pure glycerine is made by passing fats, with steam, through iron tubes heated to about 300° C. The superheated steam then saponifies the fats and pure glycerine results. I cannot say what is the effect of lime on the nitro-glycerine.

Lieutenant Soley. The process at Vonges is shown to produce a much purer article with less danger than by the other processes. Is there any reason why it is not in more common use?

Professor Munroe. The process as used at Vonges has not been generally known until at present and consequently could not be used. In Wurtz's Dictionaire de Chimie, a very recent work, it is stated that the process is not yet made public, but that they obtain with great economy and without danger nearly the theoretical yield while working on large quantities.

Commander Sampson. The lecturer has given us a very thorough and valuable description of the processes by which these powerful explosives are obtained and the thanks of the society are tendered him.

*Note*—Since presenting these notes to the Institute, I have prepared a smal l quantity of nitro-glycerine by the process used at Vonges. When the glycerine mixture and acid mixture were mixed together there was no noticeable rise in temperature and no nitrous fumes were evolved. The reaction went on slowly and quietly. After a short time the liquid appeared turbid and when, after standing for twelve hours, it was poured into a large volume of water, the explosive nitro glycerine was precipitated out. When the glycerine and sulphuric acid were first mixed considerable heat was developed and the glycerine was charred, but on repeating the experiment both of the liquids were cooled with running water and then slowly mixed with constant stirring and thus the charring was avoided. When the sulphuric acid and the glycerine are mixed sulphoglyceric acid is formed. (Pelouze, Ann. Ch. Phys. lxiii. 21). It is probable that the nitroglycerine results from a metathetical reaction between the sulphoglyceric acid and the nitric acid, a reaction which may possibly be represented as follows.

$$\left.\begin{matrix} C_3H_5 \\ SO_2 \\ H_3 \end{matrix}\right\} O_4 + 3 \left.\begin{matrix} H \\ NO_2 \end{matrix}\right\} O = \left.\begin{matrix} C_3H_5 \\ (NO_2)_3 \end{matrix}\right\} O_3 + 2 \left.\begin{matrix} H \\ H \end{matrix}\right\} O + \left.\begin{matrix} H_2 \\ SO_2 \end{matrix}\right\} O_2$$

# THE RECORD

OF THE

# UNITED STATES NAVAL INSTITUTE.

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U. S. NAVAL ACADEMY, ANNAPOLIS,

NOVEMBER 14, 1878.

Commander A. T. MAHAN, U. S. N., in the Chair.

## NOTES ON GUM DYNAMITE OR EXPLOSIVE GELATINE.

BY PROF. CHARLES E. MUNROE, U. S. N. A.

For some time past rumors have reached this country concerning the discovery of a new explosive by Nobel which was said to possess even more power than nitro-glycerine while it was at the same time more stable and better adapted to military uses. This explosive was known as explosive gelatine or gum dynamite.

During the past summer I have collected fuller information about this substance which I take pleasure in laying before you. I first learned of it at the Exposition where several manufacturers of nitro-glycerine mixtures exhibited sheets of glue, rolled into cylinders the size of an ordinary cartridge, as representing the character and appearence of the gum dynamite cartridges; and afterward in a lecture at the Trocerdaro when M. Roux exhibited one of these rolls of glue and stated that the gum dynamite cartridge resembled it. When however I afterward saw a genuine cartridge of the gum dynamite in the laboratory of Prof. Abel at Woolwich, I found that sample to consist of a light amber-colored, gelatinous mass which lacked the coherence of sheet glue and rather resembled jelly. This specimen came from the dynamite works at Stevenson, Scotland, but, though they have received intimations from the Government that they will be allowed to manufacture it, it is not yet an article of commerce, and therefore this may not be the form in which it will appear.

From the specifications filed by H. E. Newton for Nobel in the Eng-

lish Patent Office I have learned the following facts concerning its manufacture.

It has been found by experience that liquid explosives, such as nitro-glycerine, methylic nitrate and the like are dangerous to store, transport or use, while solid explosives have been found less dangerous. Hence Nobel has been led to try and devise some plan by which these most powerful explosives could be converted into the solid form. The first step in this direction was the invention of the various forms of dynamite but while by the mixture of the nitro-glycerine with various inert solid absorbents a solid explosive was obtained, this advantage in state was attended with a loss in the power and for some purposes in the efficiency of the explosive. Consequently he has sought for a means for producing the solid form without any loss of power and in the gum dynamite this is attained.

He has found that nitro-glycerine, methylic nitrate and other explosive liquids exert a solvent action on collodion gun cotton similar to that exerted by a mixture of ether and alcohol upon it and that, as the ether and alcohol solution called collodion when concentrated by evaporation leaves the gelatinous film on the photographic plate, so the nitro-glycerine when it has dissolved sufficient of the soluble gun cotton gelatinizes and the solid state is attained.

In some of the explosive liquids, such as methylic nitrate for instance, the soluble cotton readily dissolves at the ordinary temperature but it does not dissolve easily in nitro-glycerine unless it is heated. Therefore he proposes two methods of manufacture. To produce the gum dynamite in the cold he adds to the nitro-glycerine such a solvent for the gun cotton as glycerylic acetic, ethylic acetic or methylic acetic ethers, acetic acid, a mixture of ether and alcohol, acetone, nitro-benzol, dinitro-benzol, methylic nitrate, ethylic nitrate and analogous substances to effect the solution. The quantity of solvent which must be used depends upon the nature of the substance chosen but as a rule about ten ounces of the nitro-glycerine taken to be gelatinized will be found sufficient.

If however the nitro-glycerine be gently heated in a water bath it acquires the property of dissolving collodion cellulose without the addition of the promoting solvent. On account of this property the promoting solvent can be entirely dispensed with or when it is found advantageous to use the promoting solvent we can by heating reduce the quantity used to two per cent. or even less. Since collodion gun cotton is rarely, if ever, homogeneous in composition, its solubility in nitro-gly-

cerine, even when aided by the heat of a water bath, will be found to vary; therefore it needs must be left to the judgment and experience of the manufacturer to add or not a predisposing solvent as above described, and the necessary proportion will be readily ascertained in practice, after a little experience.

This process of gelatinization necessiates, (1) that the explosive liquid shall contain no impurity or foreign matter capable of counteracting its power of dissolving nitrated cellulose; (2) that only such nitrated cellulose or analogous substance is to be used as will readily dissolve in and gelatinize the the explosive liquid; (3) that the solution of the nitrated cellulose (especially if that substance is twisted or compressed) shall be facilitated by mechanical stirring or kneading so as to allow the solvent access to all parts of the gun cotton.

The explosive jelly obtained by this process can be easily pressed into cartridges or any other forms convenient for use. It may be exposed in shallow trays, allowed to harden and then be cut in strips which can be rolled into cartridges. For certain purposes, and especially for military use, it is of importance to be able to dilute or modify the explosive sensitiveness of gelatinized nitro-glycerine to a degree suited to the purpose in view. This is done by adding a quantity of a non-explosive or sluggishly explosive substance possessing the property of dissolving the gelatinizing substance and of mixing with the nitro-glycerine. The solvent substances before mentioned produce this result. They serve not only the purpose of rendering the gelatinized nitro-glycerine less sensitive to concussion, but also reduce the quickness with which it explodes and lower the temperature at which it hardens or congeals by cold. The least volatile substances are to be preferred since they cannot become inoperative through evaporation.

The addition of these substances lowers the percentage of oxygen and raises the percentage of carbon and hydrogen contained in the mixture. To make up for the lost power it is proposed to add to the mixture enough finely divided sodic or potassic nitrate, or potassic chlorate, or other suitable oxydizing material to effect the complete combustion of the excess of carbon and hydrogen in the mixture.

It can be seen that by this means an endless number of such mixtures may be made. Mr. Newton cites four different ones as indicating the different classes of mixtures which may be produced.

I. Nitro-glycerine gelatinized with from four to eight per cent. of gun cotton.

II. No. I with from one half to thirty per cent. of glycerylic acetic ether, or nitro-benzol, or a similar substance mixed with it. The wide range between one-half, and thirty per cent., is given because a very sensitive explosive is required for some purposes, and a very sluggish one for others.

III. Composition II with the addition of an oxydizing agent mixed in sufficient quantity to secure complete combustion.

IV. Composition I and II with the addition of less powerful explosives. These last mixtures, class IV, are adapted to blasting mild rock; the first class is for blasting hard rock, and the others for military purposes.

Gelatinized nitro-glycerine, when properly confined, may be exploded by means of a common fuse but the explosion is quickened and facilitated by using fulminating detonators. When hardened by cold weather gelatinized nitro-glycerine explodes more readily than frozen dynamite, still it is always a good precaution to head the charge with a primer consisting of a small cartridge of gunpowder, gun cotton, dynamite or uncongealed gelatinized nitro-glycerine.

Gelatinized nitro-glycerine to which a considerable portion of glycerylic acetic ether or nitro-benzol or di-nitro-benzol and the like have been added, not only must be fired by a strong detonator but must be confined as in a shell to exert its full power.

Captain Philip *Hess of the Austrian Engineers has made a series of most exhaustive experiments upon gum dynamite to which gum camphor had been added. The gelatine as he used it, contained four per cent. of camphor and ninety-six per cent. of gum dynamite; the gum dynamite being composed of ninety per cent. nitro-glycerine and ten per cent. soluble nitro-cellulose. This preparation formed a gelatinous, elastic, translucent, pale-yellow colored mass (Sp. Gr. 1.6.) of about the consistency of a very stiff jelly which could be easily indented or cut with a knife, and which did not exude the least trace of nitro-glycerine when strongly compressed, nor show any greasiness. It was submitted to a pressure of 15.4 kilo. per $cm^2$ without separating any nitro-glycerine. Heated up to between 50° and 60° C., it softened but did not become greasy. When ignited, it burned like dynamite or dry compressed gun cotton. When pure gum dynamite was heated slowly, it exploded at 204° C; if heated rapidly, the explosion took

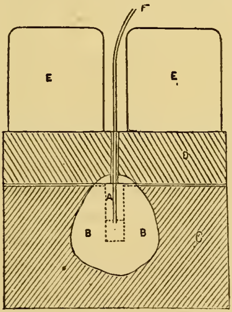
*Uber ein Neues Kriegs Sprengmittel von Filipp Hess, Mittheilungen über Gegenstände des Artillerie und Genie-Wesens, Wien.

place at 240° C. When camphor (4 per cent.) was added, the gum dynamite could be heated to from 300° to 330° C. before it exploded.

According to his experiments gum dynamite containing 4 per cent. of camphor is 25 per cent. stronger than kieselguhr dynamite No. 1, weight for weight. If we consider the normal kieselguhr dynamite as having a Sp. Gr. of 1.4., the gum dynamite is by volume forty per cent. the stronger. Compared by weight with compressed gun cotton containing 15 per cent. of water, the gum dynamite is 25 per cent. stronger; if the Sp. Gr. of the cotton be taken at 1.16, the gum dynamite is by volume 75 per cent. stronger.

M. Roux in the lecture referred to, exhibited the following apparatus which he used for determining the relative force of different explosives.

Method of comparing the force of Dynamite No. 1 with Explosive Gelatine by the effect produced by the explosion of equal charges of the two within a block of lead.




The apparatus used is shown in the Fig. It consists of a block of lead C, with a leaden cover D, which is held in place by the heavy weights E E. In the block C there is a chamber A one centimeter in diameter and four centimeters deep. Two grammes of the explosive to be tested are placed in this chamber, the remaining space is filled with water, the cover and weights are put on and then the charge is fired by means of the wire F. The force developed is measured by measuring the volume of B after the explosion. Experiment has shown that

THE AUGMENTATION OF VOLUME OF CHAMBER

| | |
|---|---|
| With Dynamite No 1 is | 43.55 $cm^3$ |
| With Explosive Gelatine is | 61.20 $cm^3$ |

The Nobel's Explosive Company of Glasgow, report * the following results from their experiments with explosive gelatine and other explosives. The tests were made in the Company's mortar with the view of instituting a comparison of the balistic power of various nitrated com pounds. The charge of explosive employed in each case, was 10

* From a circular of the Company given to me by Mr. Cuthbert.

grammes, the weight of the shot was 32 pounds, and the distance it was thrown is based upon the average of an equal number of shots fired with the several explosives. The results show that the blasting gelatine is by far the strongest explosive, for practical purposes, known, and that No. 1 and No. 2 dynamite are the cheapest explosives in the market at the present time. The results of the test were as follows.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| With | Blasting Gelatine | the shot | was | thrown | | 230.3 | links. |
| " | Nitro-Glycerine | " | " | " | " | 215 | " |
| " | Dynamite No. 1 | " | " | " | " | 173 | " |
| " | Lithofracteur | " | " | " | " | 151.3 | " |
| " | Cotton Gunpowder | " | " | " | " | 150.7 | " |
| " | Dynamite No. 2 | " | " | " | " | 118 | " |

If the balistic power of blasting gelatine is taken as 100, then in their comparison, weight for weight, the various explosives rank as follows, viz:

| | | | |
|---|---|---|---|
| Blasting Gelatine | 100. | Lithofracteur | 65.69. |
| Nitro-Glycerine | 93.36. | Cotton Gunpowder | 65.43. |
| Dynamite No. 1 | 75.11. | Dynamite No. 2 | 51.23. |

The Sociètè Gènèrale pour la Fabrication de la Dynamite, Paris, have published a pamphlet* upon Dynamite and the Explosive Gum from which I gather the following information.

By the method of manufacture employed an intimate mixture of the nitro-glycerine and the gun cotton is obtained in the form of a gelatinous solid. Thus while this substance still belongs to the family of dynamites since it has nitro-glycerine for its base, it may yet perhaps be considered as an entirely new body and as having but little in common with the numerous compositions which modern science has placed at the disposal of the industries.

This body whose power surpasses slightly that of pure nitro-glycerine, possesses all the characteristic advantages of dynamite. Ignited by contact with a burning body it burns up but does not explode except under the influence of an initial explosion like that which is usually produced by means of a fulminating exploder.

Although a recent invention the explosive gum has already been subjected to trials of its preservative character sufficiently prolonged to show that there need be no doubt as to its stability. Cartridges preserved in contact with the air during more than a year have not shown the slightest trace of alteration. Preserved in water they have not

* La Dynamite ses Caracteres et ses Effets. Notice sur la Gomme Explosible, Paris, 1878.

given up the least trace of nitro-glycerine and the substance has not lost any of its force.

The superior power of the explosive gum is due evidently to the elements which enter into its composition; the hydro-carbons and oxygen are in such proportion that their combustion is more complete than that of pure nitro glycerine.

The explosive gum tested freely in the air appears to ally itself to the slowly detonating dynamites and produces effects somewhat more analogous to those of gun cotton than to those of normal dynamite. By the plate proof made freely in the air the impression made on the plate by cartridges of gum dynamite is not as deep as that produced by a cartridge of the same weight of dynamite No. 1. On covering the cartridge with an obstacle, such as a handful of damp earth for example, the explosive gum shows its superiority over dynamite No. 1, although not notably so. But if the charges are partly imprisoned, as in a testing mortar, the gum shows a great superiority to the dynamite. Finally if the charges are closely confined as in the blast hole of a mine with sufficient tamping the explosive gum exhibits all its power and surpasses dynamite by 50 per cent.

This peculiarity will probably lead to the frequent use of resisting receptacles for this new explosive. For certain military purposes, for example, when it is employed in breaking up or overturning an obstacle by simply placing the charge against this obstacle the explosive gum should be put in metallic boxes, a measure which is already adopted in France for the ordinary dynamite and for gun cotton.

Let us examine the influence which the discovery of this new explosive will exercise upon the operations of industry and of war.

In the industries the explosive gum will advantageously displace dynamite in those cases where it is obviously advantageous to employ the most powerful explosive, as, for example, in attacking the fronts of galleries in the granitic schists, and at all times where it is economical to advance rapidly by diminishing the necessary number of blast holes and the labor required for the work. Such is again the case in submarine blasting, where the difficulties in placing the charges, the incidental costs, the employment, so onerous, of divers etc., makes it important to diminish as much as possible the number of blasts, and consequently to have recourse to the most energetic means.

But where the success of the gum dynamite appears above all to be assured is for military purposes for which we can say, that, up to the present time, there has been no wholly suitable explosive. The ordi-

nary dynamites while sufficiently stable for use in the industries, where they can be carefully looked after, do not completely meet the requirements of the army and navy. A substance formed by simply mixing mechanically nitroglycerine and its absorbents cannot be exposed, without a certain apprehension, to the vicissitudes, so variable and sometimes so dangerous, incident to a campaign on land and sea.

These considerations have led to compressed gun cotton being sometimes preferred since it does not present the same inconveniences and has above all the advantage of not freezing; but the doubts which some have always had as to the chemical stability of pyroxylin prevent its being supplied except in the moist state. And here new difficulties arise. How can we be assured of the degree of moistness of all parts of the supply during a long storage; and how may we procure rapidly and without danger under all circumstances the dry cotton which is necessary for detonating the moist cotton? Finally the relative sensitiveness of the ordinary dynamites and of cotton powder will not permit of their use in charging shells, especially for large marine ordnance.

The imperfections of the explosives intended for military purposes is demonstrated by the indecision which has existed up to the present day, in the different armies and the different countries, as to which was the most suitable substance to adopt for the end proposed. Not content with bringing forward compressed gun cotton and dynamite they have been led to try the picrate mixtures and in default of any single explosive which will answer under all circumstances, each service seeks a substance which can at least meet its needs within a certain limit.

It may appear premature to say to-day that gum dynamite has solved the problem of the true military explosive, however everything leads to this presumption. To have the greatest possible force, together with the smallest volume and with the least weight is the first element of this problem. This is undoubtedly resolved.

The chemical stability cannot be doubted by those who recognize this quality in nitro-glycerine. The experience of more than a dozen years is conclusive. Besides the new material may be preserved in water and need not be taken out until at the moment when it is to be used, and hence it cannot offer any practical difficulty from this point of view. Its mechanical stability follows from its process of manufacture. We are convinced that it can be obtained in a definite state.

The new explosive is gifted with a relative insensibility which is of the greatest importance for military uses. Cartridges of dynamite or of

gun cotton exploded in the neighborhood of a charge of gum dynamite, under such conditions that other cartridges of dynamite or of gun cotton would certainly have detonated, produced no effect on it.* Hess† found that while a kilogram of the gum dynamite containing 4 per cent. of camphor exploded in air within 25 cms. of another kilogram of the same did not affect the second mass, the explosion of a kilogram of ordinary dynamite caused the explosion of a second mass of this dynamite placed 35 cm. from the first.

By mixing camphor with gum dynamite its insensibility may be augmented at will. Whilst dynamite and cotton powder are exploded at great distances by the impact of a ball from a gun the explosive gum, rendered insensitive by this process, resists the impact of a ball from a rifle fired at 25 metres. Experiments have established this decisively.‡

The power to put into the hands of the combatants, without serious danger to them, a destructive engine of such great power ought to have a considerable influence upon the future of military operations. Should subsequent experiments show, what is highly probable, that we can charge large shells with this new explosive it will lead to the casting aside of the armors of our vessels.

* Experiments made in Denmark showed that a dynamite torpedo of 150 lbs. exploded in 10 ft. of water exploded other charges, by communicated vibrations, at 300 ft. distance. Nature, Nov. 15, 1877.

† Loc. cit.

‡ Hess, page 20.

## DISCUSSION ON THE PAPER.

Lt. Commander Brown. I would like to ask if any experiments have been made with a view to firing by electricity, and also if experiments have been made with shells loaded with gum dynamite?

Prof. Munroe. I do not know of any experiments having been made with loaded shells, but experiments have been made in firing by electricty. It may be fired in this way by the use of a detonating exploder.

Lt. Soley. I noticed that the test of the eprouvette is in general use for testing the strength of the explosives. This is the same test that was formerly used for testing gunpowder. If these explosives can be used in the eprouvette I should think that their action could be so controlled that they might be used in a gun.

Prof. Munroe. I do not feel fully equal to discussing this question, as it is not within my province yet I will say that I do not think it probable that the nitro glycerine explosives will be used for this purpose. When they detonate the motion of their molecules is so rapidly imparted to the different parts of the chamber that the projectile, as a mass, does not have time to move from its seat before the molecules of which it and the gun are formed have been set in motion and ruptured. Nothing can withstand this effect. For a very clear and interesting exposition of this subject I would refer you to an article by Prof. J. P. Cooke in the Popular Science Monthly on The Air as an Anvil.

Commander Sampson. This subject is a most important one in all its phases, and worthy of attentive study by all officers. The problem of the application of gum dynamite or other chemical agents to ordnance purposes is one whose solution would be of great benefit. One curious fact is worthy of notice and that is that the energy of the gum dynamite is greater than that of the nitro glycerine or the gun cotton of which it is made. How is this explained?

Prof. Munroe. In my lecture before the Institute on the *Conditions which Promote Explosions, I showed that when nitro glycerine exploded oxygen or oxides of nitrogen were found in the products and that when gun cotton was exploded that carbon protoxide was found in the products, thus showing incomplete combustion of the car-

* Vol. 4, p. 21.

bon. There are believed to be three different gun cottons corresponding to the three nitro glycerines. The gun cotton containing the three atoms of nitryl ($N O_2$) is the explosive gun cotton. The two lower ones are believed to exist in the collodion cotton, and hence when they are ignited the carbon in them would be still less completely burned than in the ordinary gun cotton. Now it seems to me probable that when we mix a small percentage of this with nitro glycerine that we have even more complete a combustion than we have with pure nitro glycerine and consequently more heat is developed and a large volume of gas obtained. This would give a greater energy. It may be that the gum dynamite is not a simple mixture and that the whole detonates simultaneously. While speaking of this subject I would like to call your attention to the fact that this substance was all but discovered some years ago. At that time Prof. Abel proposed the manufacture of an explosive called glyoxylin which was made by absorbing nitro glycerine with the explosive insoluble gun cotton. Had he but used the soluble gun cotton he would have discovered the gum dynamite.

Commander Mahan. How much stronger is this than gunpowder?

Prof. Munroe. The experiments cited show it to be about seven per cent. stronger than pure nitro glycerine and nitro glycerine when fired by detonation is over ten times as powerful as the same weight of gunpowder when fired by ignition.

It was moved and adopted that the thanks of the meeting be extended to Prof. Munroe.

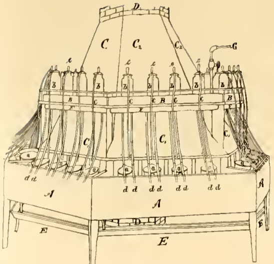


Fig. I

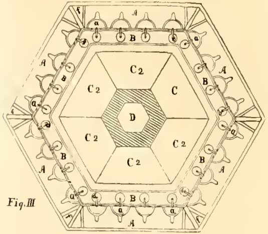


Fig. III

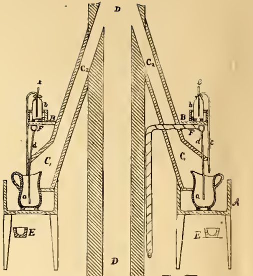


Fig. II

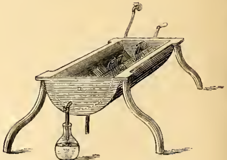


Fig. 8.

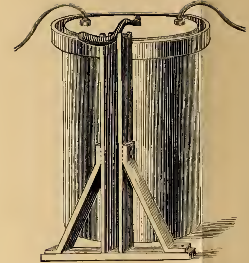


Fig. 9

Fig. 10.

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U. S. NAVY DEPARTMENT, WASHINGTON,
JANUARY 30, 1879.

Captain SAMUEL R. FRANKLIN, U. S. N., in the Chair.

# THE NAUTICAL ALMANAC.

By PROFESSOR SIMON NEWCOMB, U. S. NAVY, LL.D., PH.D., &c., &c., &c., SUPERINTENDENT OF NAUTICAL ALMANAC.

Although the Nautical Almanacs of the world, at the present time, are of comparatively recent origin, they have grown from small beginnings, the tracing of which is not unlike that of the origin of species by the naturalist of the present day. Notwithstanding its familiar name it has always been designed rather for astronomical than for nautical purposes. Such a publication would have been of no use to the navigator before he had instruments with which to measure the altitudes of the heavenly bodies. The earlier navigators seldom ventured out of sight of land, and, during the night they are said to have steered by the "Cynosure" or constellation of the Great Bear, a practice which has brought the name of the contsellation into our language of the present day to designate an object on which all eyes are intently fixed. This constellation was a little nearer the pole in former ages than at the present time; still its distance was always so great that its use, as a mark of the northern point of the horizon, does not inspire us with great respect for the accuracy with which the ancient navigators sought to shape their course.

The Nautical Almanac of the present day had its origin in the Astronomical Ephemerides called forth by the needs of predictions of celestial motions both on the part of the astronomer and the citizen. So long as astrology had a firm hold on the minds of men, the positions of the planets were looked to with great interest. The theories of Ptolemy, although founded on a radically false system, neverthe-

less sufficed to predict the position of the sun, moon and planets with all the accuracy necessary for the purposes of the daily life of the ancients or the sentences of their astrologers. Indeed, if his tables were carried down to the present time, the positions of the heavenly bodies would be so few degrees in error that their recognition would be very easy. The times of most of the eclipses would be predicted within a few hours, and the conjunctions of the planets within a few days. Thus it was possible for the astronomers of the middle ages to prepare for their own use, and that of the people, certain rude predictions respecting the courses of the sun and moon and the aspect of the heavens, which served the purpose of daily life and perhaps lessened the confusion arising from their complicated calendars. In the signs of the zodiac and the different effects which follow from the sun and moon passing from sign to sign, still found in our farmers' almanacs, we have the dying traces of these ancient ephemerides.

The great Kepler was obliged to print an astrological almanac in virtue of his position as astronomer of the court of the King of Austria. But notwithstanding the popular belief that astronomy had its origin in astrology the astronomical writings of all ages seem to show that the astronomers proper never had any belief in astrology. To Kepler himself the necessity for preparing this almanac was a humiliation to which he submitted only through the pressure of poverty. Subsequent ephemerides were prepared with more practical objects. They gave the longitudes of the planets, the position of the sun, the time of rising and setting, the prediction of eclipses etc.

They have, of course, gradually increased in accuracy as the tables of the celestial motions were improved from time to time. At first they were not regular, annual publications, issued by governments, as at the present time, but the works of individual astronomers who issued their ephemerides for several years in advance, at irregular intervals. One man might issue one, two or half a dozen such volumes, as a private work, for the benefit of his fellows and each might cover as many years as he thought proper.

The first publication of this sort, which I have in my possession, is the Ephemerides of Manfredi, of Bonn, computed for the years 1715 to 1725, in two volumes.

Of the regular annual ephemerides the earliest, so far as I am aware, is the "*Connaissance des Temps*" or French Nautical Almanac. The first issue was in the year 1679, by Picard, and it has been continued without interruption to the present time. Its early numbers were, of

course, very small, and meagre in their details. They were issued by the astronomers of the French Academy of Science, under the combined auspices of the Academy and the Government. They included not merely predictions from the tables but also astronomical observations made at the Paris Observatory or elsewhere. When the Bureau of longitudes was created in 1795, the preparation of the work was entrusted to it and has remained in its charge until the present time. As it is the oldest, so, in respect at least to number of pages, it is the largest ephemeris of the present time. The astronomical portion of the volume for 1879 fills more than seven hundred pages, while the table of Geographical positions, which has always been a feature of the work, contains nearly 100 pages more.

The first issue of the British Nautical Almanac was that for the year 1767 and appeared in 1766. It differs from the French Almanac in owing its origin entirely to the needs of navigation. The British nation, as the leading maritime power of the world, was naturally interested in the discovery of a method by which the longitude could be found at sea. As most of my hearers are probably aware, there was, for many years, a standing offer by the British Government, of ten thousand pounds for the discovery of a practical and sufficiently accurate method of attaining this object. If I am rightly informed, the requirement was that a ship should be able to determine the Greenwich time within two minutes, after being six months at sea. When the office of Astronomer Royal was established in 1765, the duty of the incumbent was declared to be "to apply himself with the most exact care and diligence to the rectifying the Tables of the Motions of the Heavens, and the places of the Fixed Stars in order to find out the so much desired Longitude at Sea for the perfecting the Art of Navigation."

About the middle of the last century the lunar tables were so far improved, that Dr. Maskelyne considered them available for attaining this long wished for object. The method which I think was then, for the first time, proposed was the now familiar one of lunar distances. Several trials of the method were made by accomplished gentlemen who considered that nothing was wanting to make it practical at sea but a Nautical Ephemeris. The tables of the moon, necessary for the purpose, were prepared by Tobias Mayer of Gottingen, and the regular annual issue of the work was commenced in 1766, as already stated. Of the reward which had been offered three thousand pounds were paid to the widow of Mayer and three thousand pounds to the

celebrated mathematician Euler for having prepared the theorems used by Mayer in the construction of his tables. The issue of the Nautical Ephemeris was entrusted to Dr. Maskelyne. Like other publications of this sort this ephemeris has gradually increased in extent. During the first 60 or 70 years the data were extremely meagre, including only such as were considered necessary for the determination of positions.

In 1830 the subject of improving the Nautical Almanac was referred by the Lord Commissioners of the Admiralty to a committee of the Astronomical Society of London. A sub-committee, including eleven of the most distinguished astronomers and one scientific navigator made an exhaustive report recommending a radical re-arrangement and improvement of the work. The recommendations of this committee were first carried into effect in the Nautical Almanac for the year 1834. The arrangement of the Navigator's Ephemeris then devised has been continued in the British Almanac to the present time.

A good deal of matter has been added to the British Almanac during the forty years and upwards which have elapsed, but it has been gotten in rather by using smaller type and closer printing than by increasing the number of pages. The almanac for 1834 contains five hundred and seventeen pages and that for 1880 five hundred and nineteen pages. The general aspect of the page is now somewhat crowded, yet, considering the quantity of figures on each page the arrangement is marvelously clear and legible.

The Spanish *Almanaque Nautico* has been issued since the beginning of the century. Like its fellows it has been gradually enlarged and improved, in recent times, and is now of about the same number of pages with the British and American almanacs. As a rule there is less matter on a page, so that the data actually given are not so complete as in some other publications.

In Germany two distinct publications of this class are issued, the one purely astronomical, the other purely nautical.

The astronomical publication has been issued for more than a century under the title of "*Berliner Astronomisches Jahrbuch.*" It is intended principally for the theoretical astronomer, and in respect to matter necessary to the determinations of positions on the earth it is rather meagre. It is issued by the Berlin Observatory, at the expense of the government.

The companion of this work, intended for the use of the German marine, is the "*Nautisches Jahrbuch,*" prepared and issued under the

direction of the minister of commerce and public works. It is copied largely from the British Nautical Almanac, and in respect to arrangement and data is similar to our American Nautical Almanac, prepared for the use of navigators, giving, however, more matter, but in a less convenient form. The right ascension and declination of the moon are given for every three hours instead of for every hour; one page of each month is devoted to eclipses of Jupiter's satellites, phenomena which we never consider necessary in the nautical portion of our own almanac. At the end of the work the apparent positions of seventy or eighty of the brightest stars are given for every ten days, while it is considered that our own navigators will be satisfied with the mean places for the beginning of the year. At the end is a collection of tables which I doubt whether any other than a German navigator would ever use. Whether they use them or not I am not prepared to say.

The preceding are the principal astronomical and nautical ephemerides of the world, but there are a number of minor publications, of the same class, of which I cannot pretend to give a complete list. Among them is the Portuguese Astronomical Ephemeris for the meridian of the University of Coimbra, prepared for Portuguese navigators. I do not know whether the Portuguese navigators really reckon their longitudes from this point: if they do the practice must be attended with more or less confusion. All the matter is given by months, as in the solar and lunar ephemeris of our own and the British Almanac. For the sun we have its longitude, right ascension and declination, all expressed in arc and not in time. The equation of time and the sidereal time of mean noon complete the ephemeris proper. The positions of the principal planets are given in no case oftener than for every third day. The longitude and latitude of the moon are given for noon and midnight. One feature not found in any other almanac is the time at which the moon enters each of the signs of the zodiac. It may be supposed that this information is designed rather for the benefit of the Portuguese landsman than of the navigator. The right ascensions and declinations of the moon and the lunar distances are also given for intervals of twelve hours. Only the last page gives the eclipses of the satellites of Jupiter. The Fixed Stars are wholly omitted.

An old ephemeris, and one well known in astronomy, is that published by the Observatory of Milan, Italy, which has lately entered upon the second century of its existence. Its data are extremely meagre and of no interest whatever to the navigator. The greater part of the volume is taken up with observations at the Milan Observatory.

Since taking charge of the American Ephemeris I have endeavored to ascertain what nautical almanacs are actually used by the principal maritime nations of Europe. I have been able to obtain none except those above mentioned. As a general rule I think the British Nautical Almanac is used by all the northern nations, as already indicated. The German Nautical *Jahrbuch* is principally a reprint from the British. The Swedish navigators, being all well acquainted with the English language, use the British Almanac without change. The Russian Government however prints an explanation of the various terms in the language of their own people and binds it in at the end of the British Almanac. This explanation includes translations of the principal terms used in the heading of pages, such as the names of the months and days, the different planets, constellations and fixed stars and the phenomena of angle and time. They have even an index of their own in which the titles of the different articles are given in Russian. This explanation occupies, in all, seventy-five pages—more than double that taken up by the original explanation.

One of the first considerations which strikes us in comparing these multitudinous publications, is the confusion which must arise from the use of so many meridians. If each of these southern nations, the Spanish and Portuguese for instance, actually use a meridian of their own, the practice must lead to great confusion. If their navigators do not do so, but refer their longitudes to the meridian of Greenwich, then their almanacs must be as good as useless. They would find it far better to buy an ephemeris referred to the meridian of Greenwich than to attempt to use their own. The northern nations, I think, have all begun to refer to the meridian of Greenwich, and the same thing is happily true of our own marine. We may, therefore, hope that all commercial nations will, before long, refer their longitudes to one and the same meridian, and the resulting confusion be thus avoided.

The preparation of the American Ephemeris and Nautical Almanac was commenced in 1849, under the superintendence of the late Rear Admiral, then Lieutenant Davis. The first volume, as you are all probably aware, was that for the year 1855. Both in the preparation of that work and in the connected work of mapping the country, the question of the meridians to be adopted was one of the first importance, and received great attention from Admiral Davis, who made an able report on the subject. Our situation was, in some respects, peculiar, owing to the great distance which separated us from Europe, and the uncertainty of the exact difference of longitude between the two con-

tinents. It was hardly practicable to refer longitudes in our own country to any European meridian. The attempt to do so would involve continual changes as the trans-Atlantic longitude was from time to time corrected. On the other hand, in order to avoid confusion in navigation, it was essential that our navigators should continue to reckon from the meridian of Greenwich. The trouble arising from uncertainty of the exact longitude does not affect the navigator, because, for his purpose, astronomical precision is not necessary.

The wisest solution was probably that embodied in the Act of Congress, approved September 28th, 1850, on the recommendation of Lieut. Davis, if I mistake not. "The meridian of the Observatory at Washington shall be adopted and used as the American meridian for all astronomical purposes, and the meridian of Greenwich shall be adopted for all nautical purposes." The execution of this law necessarily involves the question "What shall be considered astronomical and what nautical purposes?" Whether it was from the difficulty of deciding this question, or from nobody's remembering the law, the latter has been practically a dead letter. Surely, if there is any region of the globe which the law intended should be referred to the meridian of Washington, it is the interior of our own country, yet, notwithstanding the law, all acts of Congress relating to the territories have, so far as I know, referred everything to the meridian of Greenwich and not to that of Washington. Even the maps issued by our various surveys are referred to the same trans-Atlantic meridian. The absurdity culminated in a local map of the City of Washington and the District of Columbia, issued by private parties, in 1861, in which we find even the meridians passing through the City of Washington referred to a supposed Greenwich.

This practice has led to a confusion which may not be evident at first sight, but which is so great and permanent that it may be worth explaining. If, indeed, we could actually refer all our longitudes to an accurate meridian of Greenwich in the first place; if, for instance, any western region could be at once connected by telegraph with the Greenwich Observatory, and thus exchange longitude signals, night after night, no trouble or confusion would arise from referring to the meridian of Greenwich. But this, practically, cannot be done. All our interior longitudes have been and are determined differentially by comparison with some point in this country. One of the most frequent points of reference used this way has been the Cambridge Observatory. Suppose then a surveyor at Omaha makes a telegraphic longitude de-

termination between that point and the Cambridge Observatory. Since he wants his longitude reduced to Greenwich, he finds some supposed longitude of the Cambridge Observatory from Greenwich and adds that to his own longitude. Thus what he gives is a longitude actually determined, plus an assumed longitude of Cambridge, and unless the assumed longitude of Cambridge is distinctly marked on his maps, we may not know what it is.

After a while a second party determines the longitude of Ogden from Cambridge. In the mean time, the longitude of Cambridge from Greenwich has been corrected, and we have a longitude of Ogden which will be discordant with that of Omaha, owing to the change in the longitude of Cambridge. A third party determines the longitudes of, let us suppose, St. Louis from Washington, he adds the assumed longitudes of Washington from Greenwich what may not agree with either of the longitudes of Cambridge and gets his longitude. Thus we have a series of results for our western longitude all nominally referred to the meridian of Greenwich, but actually referred to a confused collection of meridians, nobody knows what. If the law had only provided that the longitude of Washington from Greenwich should be invariably fixed at a certain quantity say 77° 3′ this confusion would not have arisen. It is true that the longitude thus established by law might not have been perfectly correct, but this would not cause any trouble nor confusion. Our longitude would have been simply referred to a certain assumed Greenwich, the small error of which would have been of no importance to the navigator or astronomer. It would have differed from the present system only in that the assumed Greenwich would have been invariable instead of dancing about from time to time as it has done under the present system. You understand that when the astronomer, in computing an interior longitude, supposes that of Cambridge from Greenwich to be a certain definite amount, say $4^h\ 44^m\ 30,^s$ what he actually does is to count from a meridian just that far east of Cambridge. When he changes the assumed longitude of Cambridge he counts from a meridian further east or further west of his former one: in other words he always counts from an assumed Greenwich, which changes its position from, time to time, relative to our own country.

Having two meridians to look after, the form of the American ephemeris, to be best adapted to the wants both of navigators and astronomers, was necessarily peculiar. Had our navigators referred their longitudes to any meridian of our own country the arrangement

of the work need not have differed materially from that of foreign ones. But being referred to a meridian far outside our limits and at the same time designed for use within those limits, it was necessary to make a division of the matter. Accordingly the American Ephemeris has always been divided into two parts; the first for the use of navigators, referred to the meridian of Greenwich, the second for that of astronomers, referred to the meridian of Washington. The division of the matter without serious duplication is more easy than might at first be imagined. In explaining it, I will take the ephemeris as it now is, with the small changes which have been made from time to time.

One of the purposes of any ephemeris, and especially of that of the navigators, is to give the position of the heavenly bodies at equidistant intervals of time, usually one day. Since it is noon at some point of the earth all the time, it follows that such an ephemeris will always be referred to noon at some meridian. What meridian this shall be is purely a practical question, to be determined by convenience and custom. Greenwich noon, being that necessarily used by the navigator, is adopted as the standard, but we must not conclude that the ephemeris for Greenwich noon is referred to the meridian of Greenwich in the sense that we refer a longitude to that meridian. Greenwich noon is $18^h\ 51^m\ 48^s$, Washington mean time; so the ephemeris which gives data for every Greenwich noon may be considered as referred to the meridian of Washington giving the data for $17^h\ 51^m\ 48^s$, Washington time, every day. The rule adopted therefore is to have all the ephemerides which refer to absolute time, without any reference to a meridian, given for Greenwich noon, unless there may be some special reason to the contrary. For the needs of the navigator and the theoretical astronomer these are the most convenient epochs.

Another part of the ephemeris gives the position of the heavenly bodies, not at equi-distant intervals, but at transit over some meridian. For this purpose the meridian of Washington is chosen for obvious reasons. The astronomical part of our ephemeris therefore gives the positions of the principal fixed stars, the sun, moon, and all the larger planets at the moment of transit over our own meridian.

The third class of data in the ephemeris comprises phenomena to be predicted and observed. Such are eclipses of the sun and moon, occultations of fixed stars by the moon, and eclipses of Jupiter's satellites. These phenomena are all given in Washington mean time as being most convenient for observers in our own country. There is a partial exception however in the case of eclipses of the sun and moon. The

former are rather for the world in general than for our own country, and it was found difficult to arrange them to be referred to the meridian of Washington without having the maps referred to the same meridian. Since, however, the meridian of Greenwich is most convenient outside of our own territory, and since but a small portion of the eclipses are visible within it, it is much the best to have the eclipses referred entirely to the meridian of Greenwich. I am the more ready to adopt this change because when the eclipses are to be computed for our own country the change of meridians will be very readily understood by those who make the computation.

It may be interesting to say something of the tables and theories from which the astronomical ephemerides are computed. To understand them completely it is necessary to trace them to their origin. The problem of calculating the motions of the heavenly bodies and the changes in the aspect of the celestial sphere was one of the first with which the students of astronomy were occupied. Indeed, in ancient times, the only astronomical problems which could be attacked were of this class, for the simple reason that without the telescope and other instruments of research it was impossible to form any idea of the physical constitution of the heavenly bodies. To the ancients the stars and planets were simply points or surfaces in motion. They might have guessed that they were globes like that on which we live but they were unable to form any theory of the nature of these globes. Thus, in the Almagest of Ptolemy, the most complete treatise on the ancient astronomy which we possess, we find the motions of all the heavenly bodies carefully investigated and tables given for the convenient computation of their positions. Crude and imperfect though these tables may be they were the beginnings from which those now in use have arisen.

No radical change was made in the general principles on which these theories and tables were constructed until the true system of the world was propounded by Copernicus. On this system the apparent motion of each planet in the epicycle was represented by a motion of the earth around the sun, and the problem of correcting the position of the planet on account of the epicycle was reduced to finding its geocentric from its heliocentric position. This was the greatest step ever taken in theoretical astronomy, yet it was but a single step. So far as the materials were concerned and the mode of representing the planetary motions, no other radical advance was made by Copernicus. Indeed it is remarkable that he introduced an epicycle which was not

considered necessary by Ptolemy in order to represent the inequalities in the motions of the planets around the sun.

The next great advance made in the theory of the planetary motion was the discovery by Kepler of the celebrated laws which bear his name. When it was established that each planet moved in an ellipse having the sun in one focus it became possible to form tables of the motions of the heavenly bodies much more accurate than had before been known. Such tables were published by Kepler in 1632, under the name of Rudolphian tables, in memory of his patron, the emperor Rudolph. But the laws of Kepler took no account of the action of the planets on each other. It is well known that if each planet moved only under the influence of the gravitating force of the sun its motion would accord rigorously with the laws of Kepler, and the problems of theoretical astronomy would be greatly simplified. When therefore the results of Kepler's laws were compared with ancient and modern observations it was found that they were not exactly represented by the theory. It was evident that the elliptic orbits of the planets were subject to change, but it was entirely beyond the power of investigation, at that time, to assign any cause for such changes. Notwithstanding the simplicity of the causes which we now know to produce them, they are in form extremely complex. Without the knowledge of the theory of gravitation it would be entirely out of the question to form any tables of the planetary motions which would at all satisfy our modern astronomers.

When the theory of universal gravitation was propounded by Newton he showed that a planet subjected only to the gravitation of a central body, like the sun, would move in exact accordance with Kepler's laws. But by his theory the planets must attract each other and these attractions must cause the motions of each to deviate slightly from the laws in question. Since such deviations were actually observed it was very natural to conclude that they were due to this cause, but how shall we prove it? To do this with all the rigor required in a mathematical investigation it is necessary to calculate the effect of the mutual action of the planets in changing their orbits. This calculation must be made with such precision that there shall be no doubt respecting the results of the theory. Then its results must be compared with the best observations. If the slightest outstanding difference is established there is something wrong and the requirements of astronomical science are not satisfied. The complete solution of this problem was entirely beyond the power of Newton. When his methods of research

were used he was indeed able to show that the mutual action of the planets would produce deviations in their motions of the same general nature with those observed, but he was not able to calculate these deviations with numerical exactness. His most successful attempt in this direction was perhaps made in the case of the moon. He showed that the sun's disturbing force on this body would produce several inequalities the existence of which had been established by observation, and he was also able to give a rough estimate of their amount, but this was as far as his method could go. A great improvement had to be made, and this was effected not by English but by continental mathematicians.

The latter saw clearly that it was impossible to effect the required solution by the geometrical mode of reasoning employed by Newton. The problem, as it presented itself to their minds, was to find algebraic expressions for the positions of the planets at any time. The latitude, longitude and radius vector of each planet are constantly varying, but they each have a determined value at each moment of time. They may therefore be regarded as functions of the time, and the problem was to express these functions by algebraic formulæ. These algebraic expressions would contain, besides the time, the elements of the planetary orbits to be derived from observation. The time which we may suppose to be represented algebraically by the symbol $t$, would remain as an unknown quantity to the end. What the mathematician sought to do was to present the astronomer with a series of algebraic expressions containing $t$ as an indeterminate quantity, and so, by simply substituting for $t$ any year and fraction of a year whatever, 1600, 1700, 1800, for example, the result would give the latitude, longitude or radius vector of a planet.

The problem as thus presented was one of the most difficult we can conceive of, but the difficulty was only an incentive to attacking it with all the greater energy. So long as the motion was supposed purely elliptical, so long as the action of the planets was neglected, the problem was a simple one, requiring for its solution only the analytic geometry of the ellipse. The real difficulties commenced when the mutual action of the planets was taken into account. It is, of course, out of the question to give any technical description or analysis of the processes which have been invented for solving the problem ; but a brief historical sketch may not be out of place. A complete and rigorous solution of the problem is out of the question, that is, it is impossible by any known method, to form an algebraic expression for the co-ordinates

of a planet which shall be absolutely exact in a mathematical sense In whatever way we go to work the expression comes out in the form of an infinite series of terms, each term being, on the whole, a little smaller as we increase the number. So, by increasing the number of these various terms, we can approach nearer and nearer to a mathematical exactness, but can never reach it. The mathematician and astronomer have to be satisfied when they have carried the solution so far that the neglected quantities are entirely beyond the powers of observation.

Mathematicians have worked upon the problem in its various phases for nearly two centuries, and many improvements in detail have, from time to time, been made, but no general method, applicable to all cases, has been devised. One plan is to be used in treating the motion of the moon, another for the interior planets, another for Jupiter and Saturn, another for the minor planets, and so on. Under these circumstances it will not surprise you to learn that our tables of the celestial motions do not, in general, correspond in accuracy to the present state of practical astronomy. There is no authority and no office in the world whose duty it is to look after the preparation of the formulæ I have described. The work of computing them has been almost entirely left to individual mathematicians whose taste lay in that direction, and who have sometimes devoted the greater part of their lives to calculations on a single part of the work. As a striking instance of this, the last great work on the "Motion of the Moon," that of Delaunay, of Paris, involved some fifteen years of continuous hard labor.

Hansen, of Germany, who died five years ago, devoted almost his whole life to investigations of this class and to the development of new methods of computation. His tables of the moon are those now used for predicting the places of the moon in all the ephemerides of the world.

The only successful attempt to prepare systematic tables for all the large planets is that completed by Le Verrier, just before his death; but he used only a small fraction of the material at his disposal, and did not employ the modern methods, confining himself wholly to those invented by his countrymen about the beginning of the present century. For him Jacobi and Hansen had lived in vain.

The great difficulty which besets the subject arises from the fact that mathematical processes alone will not give us the position of a planet, there being seven unknown quantities for each planet which must be determined by observations. A planet, for instance, may

move in any ellipse whatever, having the sun in one focus, and it is impossible to tell what ellipse it is, except from observation. The mean motion of a planet, or its period of revolution, can only be determined by a long series of observations, greater accuracy being obtained the longer the observations are continued. Before the time of Bradley, who commenced work at the Greenwich Observatory about 1750, the observations were so far from accurate that they are now of no use whatever unless in exceptional cases. Even Bradley's observations are in many cases far less accurate than those made now. In consequence, we have not heretofore had a sufficiently extended series of observations to form an entirely satisfactory theory of the celestial motions.

As a consequence of the several difficulties and drawbacks when the computation of our ephemeris was started, in the year 1849, there were no tables which could be regarded as really satisfactory in use. In the British Nautical Almanac the places of the moon were derived from the tables of Burckhardt published in the year 1812. You will understand, in a case like this, no observations subsequent to the issue of the tables are made use of; the place of the moon of any day, hour and minute of Greenwich time, mean time, was precisely what Burckhardt would have computed nearly a half a century before. Of the tables of the larger planets the latest were those of Bouvard, published in 1821, while the places of Venus were from tables published by Lindenau in 1810. Of course such tables did not possess astronomical accuracy. At that time, in the case of the moon, completely new tables were constructed from the results reached by Professor Airy in his reduction of the Greenwich observations of the moon from 1750 to 1830. These were constructed under the direction of Prof. Pierce and represented the places of the moon with far greater accuracy than the older tables of Burckhardt. For the larger planets corrections were applied to the older tables to make them more nearly represent observations before new ones were constructed. These corrections however have not proved satisfactory, not being founded on sufficiently thorough investigations. Indeed, the operation of correcting tables by observation, as we would correct the dead reckoning of a ship, is a makeshift, the result of which must always be somewhat uncertain, and it tends to destroy that unity which is an essential element of the astronomical ephemeris designed for permanent future use. The result of introducing them, while no doubt an improvement on the old tables, has not been all that should be desired. The general lack of unity

in the tables hitherto employed is such that I can only state what has been done by mentioning each planet in detail.

For Mercury new tables were constructed by Prof. Winlock, from formulæ published by Le Verrier, in 1846. These tables have, however, been diviating from the true motion of the planet, owing to the motion of the perhelion of Mercury subsequently discovered by Le Verrier himself. They are now much less accurate than the newer tables published by Le Verrier ten years later.

Of Venus new tables were constructed by Mr. Hill, in 1872. They are more accurate than any others, being founded on later data than those of Le Verrier, and are therefore satisfactory so far as accuracy of prediction is concerned.

The places of Mars, Jupiter and Saturn are still computed from the old tables, with certain necessary corrections to make them better represent observations.

The places of Uranus and Neptune are derived from new tables which will probably be sufficiently accurate for some time to come.

For the moon Pierce's tables have been employed up to the year 1882 inclusive. Commencing with the ephemeris for the years 1883 Hansen's tables are introduced with corrections to the mean longitude founded on two centuries of observation.

With so great a lack of uniformity, and in the absence of any existing tables which have any other element of unity than that of being the work of the same authors it is extremely desirable that we should be able to compute astronomical ephemerides from a single uniform and consistent set of astronomical data. I hope, in the course of years, to render this possible.

When our ephemeris was first commenced, the corrections applied to existing tables rendered it more accurate than any other. Since that time, the introduction into foreign ephemerides of the improved tables of Le Verrier have rendered them, on the whole, rather more accurate than our own. In one direction, however, our ephemeris will hereafter be far ahead of all others. I mean in its positions of the fixed stars. This portion of it is of particular importance to us, owing to the extent to which our Government is engaged in the determination of positions on this continent, and especially in our western territories. Although the places of the stars are determined far more easily than those of the planets, the discussion of star positions has been in almost as backward a state as planetary positions. The errors of old observers have crept in and been continued through two generations

of astronomers. A systematic attempt has been made to correct the places of the stars for all systematic errors of this kind, and the work of preparing a catalogue of stars which shall be completely adapted to the determination of time and longitude, both in the fixed observatory and in the field, is now approaching completion. The catalogue cannot be sufficiently complete to give places of the stars for determining the latitude by the zenith telescope, because for such a purpose a much greater number of stars is necessary than can be incorporated in the ephemeris.

From what I have said, it will be seen that the astronomical tables, in general, do not satisfy the scientific condition of completely representing observations to the last degree of accuracy. Few, I think, have an idea how unsystematically work of this kind has hitherto been performed. Until very lately the tables we have possessed have been the work of one man here, another there, and another one somewhere else, each using different methods and different data. The result of this is that there is nothing uniform and systematic amongst them and that they have every range of precision. This is no doubt due in part to the fact that the construction of such tables, founded on the mass of observation hitherto made, is entirely beyond the power of any one man. What is wanted is a number of men of different degrees of capacity, all co-operating on a uniform system, so as to obtain a uniform result, like the astronomers in a large observatory. The Greenwich observatory presents an example of co-operative work of this class extending over more than a century. But it has never extended its operations far outside the field of observation, reduction and comparison with existing tables. It shows clearly, from time to time, the errors of the tables used in the British Nautical Almanac, but does nothing further, occasional investigations excepted, in the way of supplying new tables. An exception to this is a great work on the theory of the moon's motion, in which Professor Airy is now engaged.

It will be understood that several distinct conditions not yet fulfilled, are desirable in astronomical tables; one is that each set of tables shall be founded on absolutely consistent data; for instance, that the masses of the planets shall be the same throughout. Another requirement is that this data shall be as near the truth as astronomical data will suffice to determine them. The third is that the results shall be correct in theory. That is, whether they agree or disagree with observations, they shall be such as result mathematically from the adopted data.

Tables completely fulfilling these conditions are still a work of the future. It is yet to be seen whether such co-operation as is necessary to their production can be secured under any arrangement whatever.

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## DISCUSSION.

In the course of the discussion which followed this paper, the reader expressed some doubts whether the navigators of the several southern nations of Europe actually used their own meridians, and inquired whether the naval officers present could give information on this point.

LIEUTENANT-COMMANDER THOMAS NELSON. The French reckon longitude from the meridian of Paris; the Spaniards from Cadiz; Portuguese from Lisbon, and the Brazilians from Rio de Janeiro.

Russians, Germans, Austrians, Danes, Swedes and Dutch all reckon longitude from Greenwich, and I believe that most all other maritime nations of any importance do the same.

CAPTAIN R. L. LAW. I would ask the Professor, if, since we commenced the publication of a Nautical Almanac, it has not caused an improvement to be made in the English Almanac? Have they not learned something from looking over ours?

PROFESSOR NEWCOMB. That is hard to say. I do not think they would admit having learned or adopted anything from ours, nor have we any right to say that they have done so. Great improvements have been made in the British Nautical Almanac since ours commenced, and, while a competition may have stimulated them, I would not say that we have in any way guided them. The most obvious effect of the competition was to reduce the price of their almanac one half, a result which may not be considered especially desirable.

LIEUTENANT LONGNECKER. Have the Portuguese such complete charts that they can refer to them and tell how far they are from Lisbon at any given point?

LIEUTENANT COMMANDER THOMAS NELSON. I think not. I am of opinion that they have but very few of their own charts in use for navigating purposes, and probably use British Admiralty or French charts.

LIEUTENANT LONGNECKER. Suppose you meet a Portuguese ship in mid ocean and ask her what longitude she is in from Lisbon, can she tell you?

LIEUTENANT-COMMANDER THOMAS NELSON. I cannot say positively, but I think in that case she would probably not give you her longitude from Lisbon; more likely from Greenwich or Paris, according to the chart she was using.

The CHAIRMAN. The Russians use their own chart in computing distances, as well as the longitude from Greenwich. That is my impression.

LIEUTENANT-COMMANDER THOMAS NELSON. The meridian of St. Petersburg is marked on most Russian charts, as well as that of Greenwich, I presume, for convenience in ascertaining by inspection the meridian distance of any place from St. Petersburg, and perhaps more particularly for finding the meridian distance between any two places in their own country. For navigating purposes, however, they use the meridian of Greenwich.

COMMANDER MC CORMICK. I move that this meeting tender a vote of thanks to Professor Newcomb, for the very interesting paper he has read to us. The subject on its face looked like a dry one, but he has certainly succeeded in making it a very interesting one.

The motion of Commander Mc Cormick was unanimously agreed to.

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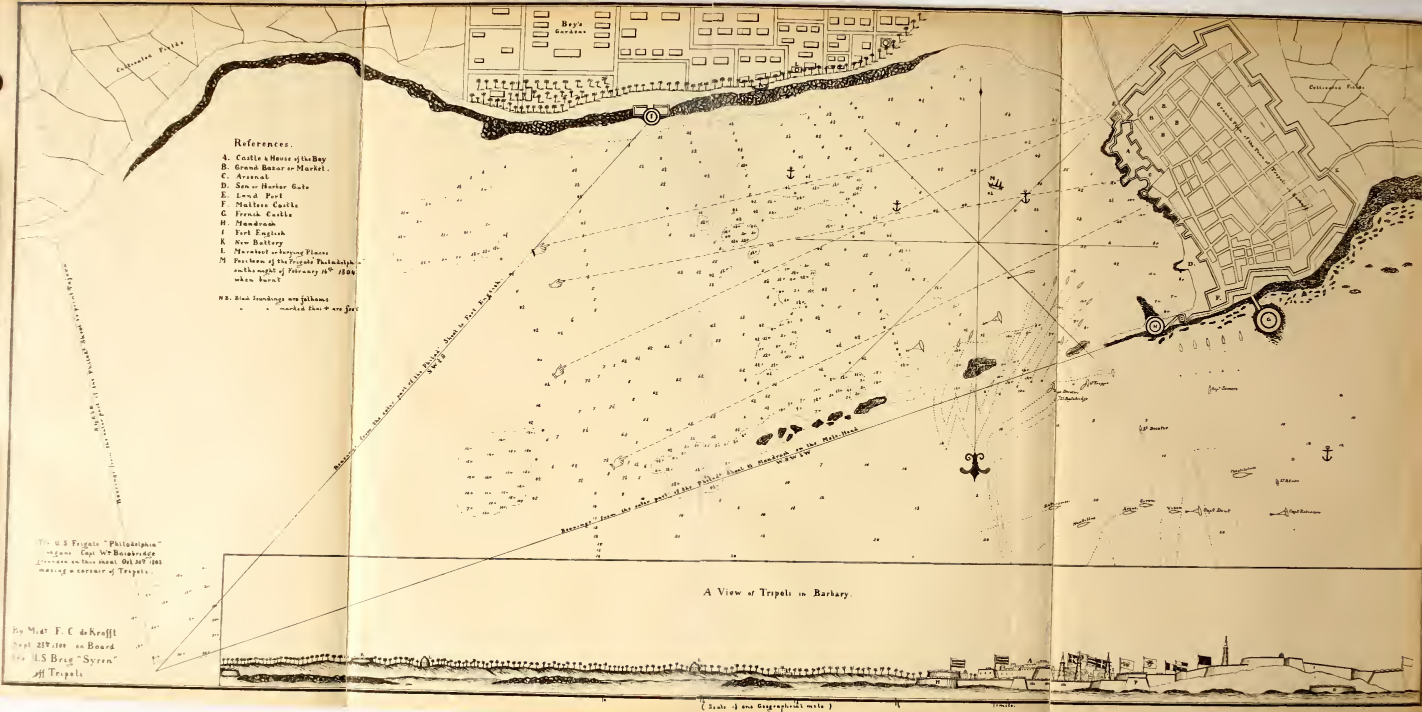
Bey's Gardens
References.
A. Castle & House of the Bey
B. Grand Bazar or Market.
C. Arsenal
D. Sea or Harbor Gate
E. Land Port
F. Maltese Castle
G. French Castle
H. Mandrach
I Fort English
K New Battery
L Marabout or burying Places
M Position of the Frigate Philadelphia on the night of February 16th 1804 when burnt
N.B. Black Soundings are fathoms
" " marked thus + are feet
The U.S Frigate "Philadelphia" 40 guns Capt Wm Bainbridge grounded on this shoal Oct 30th 1803 chasing a corsair of Tripoli.
By Midn F. C. de Krafft
Sept 25th 1804 on Board
the U.S Brig "Syren"
off Tripoli
A View of Tripoli in Barbary.
(Scale of one Geographical mile)

# THE RECORD

OF THE

# UNITED STATES NAVAL INSTITUTE.

Vol. V. 1879. No. 4.

## MAP OF TRIPOLI.

The accompanying map of the harbor of Tripoli was sketched on the spot in 1804, by Mr. F. C. de Krafft, a Midshipman on board the Brig Syren. The original is now in the possession of his son, Captain J. C. P. de Krafft, U. S. Navy, who has kindly allowed it to be lithographed, to illustrate Commodore Preble's Journal. It is valuable not only on account of its accuracy, which may be tested by comparison with the Admiralty chart, but also from its great historical interest, being the independent testimony of an eye-witness, and confirming many statements in Commodore Preble's narrative. All the important points referred to in the narrative will be found on the chart,—Fort English, the new fort built by the American prisoners, the round water battery to the west, and the mole-forts. The details of the action of the 3rd of August are given, as they appeared to Midshipman de Krafft. There is also a profile view of the harbor. I cannot help adding that I think the Institute extremely fortunate in being able to present such an illustration of a historical paper, and to publish so valuable a sketch, after it has lain in private hands for three quarters of a century.—J. R. S.

parent to every one interested in the history of the Navy.*

Difficulties with Tripoli had begun early in 1801, when the Pacha, after a series of insolent letters,† formally declared war by cutting down the flagstaff of the American consulate. His object in this was

* The letters referred to have been incorporated in the general narrative, and the journal is printed in full at the end of the paper.

† American St. Pap., Foreign Affairs, 2, 350.

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U. S. NAVAL ACADEMY, ANNAPOLIS,

JANUARY 9, 1879.

Commander A. T. MAHAN, U. S. N., in the Chair.

## OPERATIONS OF THE MEDITERRANEAN SQUADRON UNDER COMMODORE EDWARD PREBLE, IN 1803-4.

BY PROFESSOR JAMES RUSSELL SOLEY, U. S. N.

My purpose in preparing this paper for the Institute is to give such an account of the operations against Tripoli as will furnish the necessary commentary and supplement to the journal of Commodore Preble, while in command of the fleet in 1804. The original of this journal, in Commodore Preble's own hand-writing, together with a part of his correspondence, has been kindly lent me by his grandson, Edward Ernest Preble, Esq., of Portland, formerly an officer of the Navy, with his consent to its publication in the proceedings of the Institute. As the documents relate to an important period in the career of one of the most marked officers of the old Navy, as they have never before appeared in print, and as they are of absolutely the highest authority in regard to the details of naval history which they contain, the advantage of having them in a permanent and accessible form will be apparent to every one interested in the history of the Navy.*

Difficulties with Tripoli had begun early in 1801, when the Pacha, after a series of insolent letters,† formally declared war by cutting down the flagstaff of the American consulate. His object in this was

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† American St. Pap., Foreign Affairs, 2, 350.

to obtain further presents from the United States, as the price of exemption of American commerce from the depredations of his piratical cruisers. Though we had at disposal, at the time, a force sufficient for extreme measures against Tripoli, yet for three years nothing of any importance was accomplished. Three squadrons were sent out in succession. The first, under Dale, was hampered by the narrow restrictions of the President's orders, due to constitutional scruples as to the propriety of taking hostile measures before Congress had declared war. The second squadron was unfortunate in its commander, Morris, and, though some excellent things were done by the subordinates, especially Rodgers and Porter, yet the cruise, as a whole, was a failure. The third squadron came out in 1803. It was the least effective of the three in material force, but it was commanded by Edward Preble. It consisted of the following vessels:

CONSTITUTION, Commodore Preble.
PHILADELPHIA, Captain William Bainbridge.
ARGUS, Isaac Hull.
SIREN, Charles Stewart.
NAUTILUS, Richard Somers.
VIXEN, John Smith.
ENTERPRISE, Stephen Decatur.*

Preble's career at sea began in 1777, in a letter of marque. He was then sixteen years old. After one voyage he entered the service of Massachusetts as a midshipman, and he served till the close of the war in the cruisers of that State. He became noted for his bravery and coolness in action, and in all the books are abundant stories, more or less authentic, of his acts of daring during this period. For the next fifteen years, he commanded a ship in the merchant service, and, in 1798, he was commissioned a Lieutenant, at the new organization of the Navy. He received command of the Pickering, in Barry's squadron, which cruised in the West Indies during the French war, and was made a Captain while on this station. After his promotion, he commanded the Essex, and he had charge of that famous vessel on her first cruise. The Essex, under Preble, was the first American cruiser

* The Enterprise had served in Morris's squadron, under Hull, and remained out. Decatur brought out the Argus, and, on his arrival, exchanged commands with Hull, the latter being his senior. The Argus, Siren, Nautilus, and Vixen had been recently built, under an Act of Congress approved Feb. 28, 1803. The two former were 16-gun brigs, the others schooners, of 12 and 14 guns, respectively.

to go around the Cape of Good Hope, as she was later, under Porter the first to go around Cape Horn. After this, he remained on shore or unemployed till the spring of 1803, when he was ordered to the Constitution, to take the place of Commodore Morris before Tripoli.

The commanders who, up to this time, had distinguished themselves in the history of the Navy, with few exceptions, were bold and skilful seamen, energetic in preparation, ready and resolute in action, and they had won distinction by the successful management of single ships in sharp, close combats. But the service in which Preble was engaged, and the qualities he brought to it, were of a different nature. It was a service liable to so many contingencies of place, weather, and circumstance, that it needed ceaseless activity and vigilance in watching for opportunities. Its demands upon the squadron were so uncertain, and yet so frequent, that it was necessary to keep every ship ready for any service at a moment's notice. It required of the commander extreme caution and ingenuity, as well as boldness, in devising schemes for harassing the enemy; and the direction of the movements of the squadron, at the entrance of a hostile port, called for no slight exercise of tactical skill. These qualifications Commodore Preble possessed in a high degree. His movements were rapid and energetic. He was always on the watch, now in one place, now in another, wherever his directing hand was most needed. His plans were carefully laid, and he chose the best men to execute them. The operations off Tripoli were conducted with prudence, as well as determination. The discipline of the little squadron was worthy of Sir John Jervis; it was the training school of the war of 1812, as the Seven Years' war had been that of the Revolution; a school in which Stewart and Decatur, Hull and Morris, Lawrence and Macdonough, got their best lessons in the duties of officers.

When Preble arrived out in the Constitution, in September, 1803, he found at Gibraltar the fragment of Commodore Morris's squadron which had not yet gone home, consisting of the Adams, in which Morris himself was about to return, and the New York and John Adams, which were shortly to follow. The last were under the command of Commodore John Rodgers. Of the new squadron, the Nautilus had arrived in July, and the Philadelphia in August; the Vixen came in immediately after the Constitution; and the Argus and Siren were anxiously expected. The Philadelphia had only just got out when she fell in, off the coast of Spain, with the Mirboka, a cruiser belonging to Morocco, having in company a merchantman as prize. Captain Bain-

bridge discovered by a stratagem that the prize was an American, which had been captured a few days before by the Moorish captain, under orders from Hashast, the Governor of Tangier. He accordingly took possession of both the ships, and put in to Gibraltar. Leaving the prizes there, the Philadelphia went immediately to the blockade of Tripoli, then supported by the Enterprise alone.

The capture of the Mirboka changed, for the moment, the position of affairs. Preble saw, on his arrival, that his first duty was to call the government of Morocco to account for a gross violation of its treaty obligations,* in allowing the governor of Tangier to give orders to cruisers to make depredations on our commerce. If the straits were not kept open, it would be small benefit to our merchantmen to clear the inland waters of pirates. Commodore Preble decided to go to Tangier to demand satisfaction. At his request, Rodgers postponed his return, and did all in his power to forward the negotiations. Though standing above Preble on the list, he generously waived his seniority, and put aside any feeling of annoyance he might have had at the change in commanders—a change which had been necessitated by the rules of the service, and which had nothing to do with the personal fitness of the officers concerned. No one had shown himself better fitted to exercise this important trust than Rodgers, and nearly all the successful exploits of the war thus far had been due solely to him.

One of these, the capture of the Meshuda, was at this time of special importance. The Meshuda was a Tripolitan corsair, which Dale had found at Gibraltar in July, 1801, and which had remained there for two years, blockaded by one or another of our vessels. In the summer of 1803, after a real or pretended sale to the Emperor of Morocco, she got out, but was captured by the John Adams, under Rodgers, in the act of attempting to run the blockade of Tripoli. She was now lying at Gibraltar, and at Preble's request, Rodgers consented to make her surrender part of the basis of an arrangement with Morocco.

After sending the Vixen to assist the Philadelphia in the blockade of Tripoli, Preble had with him, of his immediate command, only the Constitution, Nautilus, and Enterprise. These vessels were actively employed on various duties near the straits, cruising after Moors, and watching or blockading them ; convoying American merchantmen, or warning them away from the enemy's ports ; and hovering about the coast of Morocco. The flagship was constantly moving between Gibraltar and the Moorish ports, being most of the time near Tangier,

* Treaty of July 18, 1787.

where Simpson, the American Consul, was residing, under certain restraints imposed by the local authorities.

The account of the negotiations with Morocco I give in Commodore Preble's own words. On the 22d of September, he wrote to the Navy Department, as follows:—

*Commodore Preble to the Secretary of the Navy.**

"U. S. FLAGSHIP CONSTITUTION, AT SEA,
OFF THE COAST OF BARBARY, NEAR CEUTA,
Sept. 22d, 1803.

"SIR: I had the honor to write you the 20th and enclose you various despatches as per list, since which, in consequence of information from Mogadore that several valuable American vessels were expected there, and that two galleys which the Emperor of Morocco has at Tangier were about moving, I have thought proper to countermand the orders for the Argus and Enterprise. The latter vessel is now alongside, taking in provisions for a cruise off Mogadore, to prevent our vessels from entering that port and falling into the hands of the Moors, and to watch the Moorish cruisers. The Enterprise will have to touch at Gibraltar for a few hours for additional stores. I am in great want of the Argus and Siren at the present moment, and hope they may soon arrive. The Nautilus has not yet returned from Malaga. The winds have been contrary, which has prevented her from coming down with the convoy. I want her to watch the two galleys, and a ship loaded with Moorish property, at Tangier, and prevent them from escaping, until I can learn the Emperor's determination. I understood that the vessels at Malaga were all ready to sail, and had been waiting before the Nautilus arrived. Of course I gave Lieut. Somers orders to wait at Malaga only twenty-four hours, and return to Gibraltar with what vessels he could find ready by that time. I have been endeavoring to reach Tangier Bay since the 20th, but find it impossible to beat through the straits with a westerly wind. I, however, am still striving, and shall not anchor until I reach it. Col. Lear† agrees with me that it would be imprudent for me to leave this station for Algiers, Tunis, or Tripoli, at present, and has written me a letter to that effect, which you will find among my despatches.

"As the winter is fast approaching, I conceive there will soon be very

* This, as well as all the other letters included in the paper, is from the original in the Preble collection.

† Recently appointed Consul General at Algiers.

little danger from the Tripolitans until the spring opens. In the meantime Captain Bainbridge will be able to keep them in check with the Philadelphia and Vixen. I shall send another vessel up, as soon as she can be spared from this station, to convoy a vessel to Malta with provisions, of which, by the way, there is no great stock at Gibraltar. I enclose you a list of all the consul has on hand.

"Sept. 23.

"Last evening I fell in with the Adams, Consul Cathcart on board. Capt. Campbell and Mr. Cathcart came on board the Constitution. The Bey of Tunis has refused to receive Mr. Cathcart, and positively demands a frigate. Should that demand be acceded to, it will require another frigate on our own account, to watch her motions. I suspect the demands of the Barbary Powers will increase, and will be of such a nature as to make it imprudent for our government to comply with. All of them, excepting Algiers, appear to have a disposition to quarrel with us, unless we tamely accede to any propositions they choose to make. I believe a firm and decided conduct in the first instance towards those of them who make war against us would have a good effect.

"The Emperor of Morocco has, no doubt, long been meditating war with the United States. He has only been waiting for some pretext, and the capture of the Messuda [Meshuda] by Capt. Rodgers I suppose he will allege to be a sufficient one, although I think he has no cause of complaint on that score. The Christian powers will have no chance with these people, until they determine never to pay tribute or supply them with military or naval stores or ships, and to destroy everything they can belonging to them. They send out their cruisers, and if they prove successful, it is war, and we must purchase peace, suffering them to keep all they have taken; but if they are unfortunate, and we capture their cruisers, before they have taken anything valuable, it is not war, although the orders for capturing our vessels are found on board, and we must restore all we take from them,—which enables them to commence again. I know not how long we shall be obliged to submit to this sort of treatment. The Moors are a deep, designing, artful, treacherous set of villains, and nothing will keep them so quiet as a respectable naval force near them. I think Gibraltar should never be left without a frigate and two brigs or schooners, as they can effectually prevent any cruisers from aloft passing into the Atlantic, and, at the same time, keep the Moors in check.

"The wind has the appearance of changing in favor of reaching Tan-

gier, and I must for the present conclude. Mr. Cathcart will forward despatches to the Secretary of State by the Adams, and inform him of his proceedings at Tunis.

"I have been very much engaged since I came on the station, and have only written a few lines to Mr. Madison, referring him to my despatches to you for such information or documents as belong to the State Department.

"I have the honor to be, etc., etc.,
E. Preble.

"Honorable Secretary of the Navy."

*Commodore Preble to the Secretary of State.*

"U. S. S. Constitution, cruising off the Coast of Barbary,
23 Sept., 1803.

"Sir: I have been very much hurried in preparing my despatches for the Navy Department, and although several of the papers appertain more immediately to the Department of State, I have had no time to make duplicates to forward by this conveyance, and beg leave to refer you to the Secretary of the Navy for such papers, relative to our situation with Morocco, as more immediately concern your office. I have issued orders to all the Captains under my command to capture Moorish vessels, and bring or send them to Gibraltar for examination, in consequence of the Emperor's having given orders to his cruisers to capture American property,—and one of them having actually captured the brig Celia, of Boston,—and of his having detained the brig Hannah of Salem, Joseph W. Williams, Master: for the whole of which transactions I must refer to the documents enclosed to the Secretary of the Navy.

"I have the honor to be, &c., &c.,
Edw. Preble.

"Hon. James Madison, Secretary of State."

*Commodore Preble to Consul Simpson.*

"U. S. S. Constitution,
At sea off the Rock of Gibraltar, Sept. 22, 1803.

"Sir: Adverse winds keep me from Tangier Bay. I am endeavoring to reach it, but I find it hard striving against wind and current. However, I shall keep a good lookout, and not go into port before I visit it. I feel disposed to accommodate our differences with the Emperor

on fair and honorable terms; and if he arrives at Tangier before I do, you may so inform him. I have sent three vessels off Mogadore, Sallee, and Larach [El Araiche], and one off Tetuan.

"With great esteem,
Your obedient servant,
E. PREBLE.

"JAMES SIMPSON, ESQ., Consul U. S., Tangier."

Commodore Preble soon after reached Tangier. He remained at or near that place for more than a week, in communication with the Consul, with a view of frightening the Moors into a renewal of their treaty. He then returned to Gibraltar, from which place he wrote on the 1st of October to the Secretary of the Navy.

*Commodore Preble to the Secretary of the Navy.*

"U. S. SHIP CONSTITUTION,
GIBRALTAR BAY, Oct. 1, 1803.

"SIR: I had the honor to enclose you by the U. S. Ship Adams, Capt. Morris, two letters, a monthly muster-book, and thirty-four other despatches relative to the squadron and our affairs with Morocco, and also a letter to the Secretary of State. I now enclose you a copy of the arrangement of those despatches, together with copies of sundry letters that have passed between the Emperor of Morocco, his ministers, Mr. Simpson, and myself, since that period. After a perusal of these papers, you will be convinced that the ship captured by Captain Rodgers was a Tripoline, and ought not to be given up, and that the Emperor is very desirous of peace, as his cruisers have been unsuccessful. I have no doubt but he would have discovered a different disposition, if they had been otherwise. Our squadron arriving so opportunely has disconcerted their plans, and prevented great mischief to our commerce.

"I arrived here last night from a cruise off their coast; was in Tangier Bay three times in the course of a week. They find themselves so closely watched that it will be for their interest to have peace, which I have no doubt will be established in a very few days. But to prevent any of our vessels falling into their hands, which would render it more difficult to make terms with them, I have sent the Enterprise and Nautilus off Mogadore, where several of our merchant vessels are momently expected to arrive; and the Siren, which arrived this day, will sail for the western coast in forty-eight hours. Several vessels are here

waiting for convoy for Leghorn, and other ports aloft. The moment the Argus arrives, she shall sail with them, but it will not be prudent for me to send a vessel up until then. The Emperor, with his court, are expected at Tangier next Tuesday. I shall endeavor to be there, and shall co-operate with Mr. Simpson, in such measures as are necessary and proper to the re-establishment of peace. The cruiser taken by Capt. Bainbridge is such a miserable piece of naval architecture that I do not believe we have a naval officer in our service that would be willing to attempt to cross the Atlantic in her for ten times her value. I have concluded to restore her to the Emperor, together with all his subjects in our possession, and to withdraw the orders I have given for capturing Moorish vessels, on certain conditions, which my letter of the 25th ult. to Mr. Simpson, (a copy of which is enclosed,) will explain to you. The Emperor of Morocco has such an extensive sea coast on the Atlantic and is so advantageously situated on the Straits for annoying our commerce, that it is very much for our interest to be on good terms with him. His 30-gun ship, which I met on my passage, has arrived at Lisbon, has not taken anything, and is ordered to remain there until peace is restored. The threat I made on my arrival, to sink that ship or any other of his cruisers that I might meet with, and the active vigilance of our squadron, have had a good effect on the Moors. I have no doubt but this quarrel will eventually be for our advantage, as I do not believe His Imperial Majesty will be disposed to war with us again, and we shall get clear of having anything to do with Hashast, the former governor of Tangier, who has ever been opposed to our interest.—The John Adams and New York will remain a few days longer until all is settled; and I hope by the last of this week to transmit to you by those ships satisfactory accounts of our situation relative to Morocco. * * * * * *

"The Enterprise has been new-coppered at Malta, and I shall new-rig her here as soon as she returns from off Mogadore.

"I am watering at present, and expect to sail tomorrow evening for Tangier. "I have, etc., etc.,

E. Preble.

"Hon. Robert Smith,

Secretary of the Navy."

The Constitution remained only two days at Gibraltar, returning as soon as possible to Tangier. She entered the bay on the 4th, and on the same day Commodore Preble wrote to Mr Simpson.

*Commodore Preble to Consul Simpson.*

"U. S. S. Constitution,
Tangier Bay, Oct. 4, 1803.

"I yesterday had the Mirboka's sails bent, and put on board an officer and men to bring her here. A change of wind will prevent her arrival for the present, as she is but an indifferent sailer. Indeed I cannot conceive what advantage to us or to the Emperor it can be to have her here previous to the settlement of our affairs and a re-establishment of peace, as, immediately on that event taking place, I shall deliver her up in as good or better order than when detained by us, together with all the Moors in our possession.—I certainly shall not deliver up either vessel or people previous to the renewal and ratification of our treaty. I wish exceedingly to see you on board, if only for a few minutes. Neither his Imperial Majesty nor his minister can have any objection to your visiting me for the purpose of our consulting on the best means of bringing about a speedy and happy termination of all our differences.

"With the charge of the squadrons resting on me, I cannot think of leaving my ship at present, particularly as they have not themselves the liberality to allow you to come on board. If they wish a hostage, the officer who brings this will remain on shore until your return; but I should presume that they cannot require any other security than your family.

"I have the honor to be, with real esteem and respect,
E. Preble.

"James Simpson, Esq., Consul."

Simpson could not come off, but informed the Commodore that the Emperor was expected, and asked that the ship might salute him. Preble replied as follows:

*Commodore Preble to Consul Simpson.*

"U. S. S. Constitution, Tangier Bay.
Six P. M., Oct. 4, 1803.

"I am honored with your communication of this evening. I shall not send a boat on shore until I have the Emperor's permission, but shall wait your communications by a shore boat.

"As you think it will gratify his Imperial Majesty, I shall salute him and dress ship; and if he is not disposed to be pacific, *I will salute him again.* *

"Respectfully,
E. Preble."

* Underscored in the original.

*To the Same.*

"U. S. S. Constitution, Tangier Bay,
6 P. M., Oct. 5, 1803.

"I am honored with yours of this afternoon, and shall wait until to-morrow to hear the result of your communication with the Emperor. If Hashast is continued in power, with additional honors conferred upon him, we cannot have anything friendly to expect. Of course, I shall be under the necessity of employing my whole force in the best possible way for the protection of our commerce, and to avenge the insult and indignity offered our flag. I, however, still hope that every thing may be amicably adjusted."

On the 6th, the Consul came on board the Constitution, and had an interview with Commodore Preble. The New York and the John Adams joined company on the same day. All the ships were kept clear for action, the men sleeping at quarters. On the afternoon of the 6th, the Emperor arrived at Tangier. Upon seeing the warlike preparations of the squadron, he announced that he had no intention of breaking the peace, and he was accordingly saluted. Friendly relations were established, and the remaining letters show the progress of the negotiations.

*To the Same.*

"U. S. Ship Constitution,
Oct. 7, 1803.

"I am honored with your favor and the Emperor's present, for which I beg you to present my thanks. The salute I meant as a compliment of respect to His Imperial Majesty, on his appearance at the Fort, and I am gratified that it was received by him as such.

"My boat, as I before observed, will attend you to-morrow at 7 o'clock."

*To James Simpson, Esq.*

"8th Oct., 1803, 3 P. M.

"The order for the release of the vessel at Mogadore is an act of justice on the part of the Emperor, and augurs favorable things to us.

"I shall be ready to pay my respects to His Imperial Majesty the moment you give me notice that I shall be favorably received, and that I shall not be detained on shore one moment contrary to my wishes.

"I ardently wish this business may be speedily settled."

*Commodore Preble to Consul Simpson.*

"U. S. S. CONSTITUTION, TANGIER BAY,
8th Oct., 1803.

"I am honored with your favor of this date, and have duly considered its contents. I think your arguments so far conclusive that I shall not hesitate in giving up the Mirboka, and am authorized by Commodore Rodgers to assure you that he will do the same by the Meshuda,—on the Emperor's renewal and acknowledgment of the Treaty of Peace and friendship entered into between the Emperor and Sidy Mahomet, his father, and the United States, in the year 1786, and the fulfilment of his promise to release all American property and subjects he may have in his possession.

"I am fully aware of the happy combination of circumstances which has facilitated that so much desired object of our government without the agency of money, or even the promise of any future tribute or present: either of which must have degraded us in the eyes of these barbarians; and would have only been a prelude to greater insolence and demands.

"If the arguments adduced in favor of the restoration of the Mirboka and Meshuda should appear rather specious to the Secretary of State, I feel confident they will give place to the importance of the object accomplished thereby. Indeed your extract from his instructions ensures to us his approbation of the measures we have taken, for the security of our large and increasing commerce to this part of the world, by the establishment of an honorable and permanent peace."

The basis of the negotiation was the mutual restitution of all property and subjects detained or captured, and the disavowal, on the part of the Emperor, of the acts of Hashast, the Governor of Tangier. On the 10th, Commodore Preble and the Consul had interviews with the Emperor and his Minister, which resulted in the renewal and ratification of the Treaty of 1787, and in the issue of orders to all Moorish officers to abstain from depredations on American commerce; Commodore Preble having, on his part, revoked his orders to capture all Moorish vessels. The terms of the agreement were carried out at once, and, on the 15th, the fleet was once more at Gibraltar. Two days afterwards, the New York and John Adams returned to the United States, and Commodore Preble was left free to devote himself to his main object,—the reduction of Tripoli.

On assembling his ships at Gibraltar, Preble made a formal declara-

tion of the blockade of Tripoli, at the time actually maintained by the Philadelphia and Vixen. It was too late in the season for active operations, but the new force had to be put in order and disciplined for the work of the next summer. The Siren was sent to Leghorn on convoy duty, and on the 13th of November, Preble sailed for Algiers, where he landed Lear, the new Consul General.

It was several days before this, towards the end of October, that the Philadelphia met with the accident that resulted in her capture. The story of the loss of the vessel has been often told, and is especially well told in Admiral Porter's life of his father; so that it need not be dwelt upon here. The elder Porter was first Lieutenant of the Philadelphia, and she was commanded by Bainbridge. The blockade of Tripoli at this season was a service requiring especial caution; and neither Bainbridge nor Porter had an excess of this quality. Still, the grounding of the Philadelphia was one of those accidents for which it would be hard to blame any one: and the officers paid a severe penalty in a year and a half of close confinement in Tripoli.

Preble first heard of the catastrophe from an English frigate which he met off Sardinia, on his way to Tripoli. He went at once to Malta for further intelligence. Here he found letters from Bainbridge, confirming the report. The loss of the ship caused him the greatest anxiety. "It distresses me beyond description," he said, in his official report to the Secretary of the Navy. Besides the loss of the frigate itself, which was fully one-third of his force, there was the additional loss of the officers and men, and complicated questions would arise in regard to ransom, increasing the difficulty of securing a peace honorable to the United States. It was a stroke at the outset that would have daunted any but the most resolute; but it only stimulated Preble to greater energy and effort.

There were many things that made the situation a specially hard one. The bad season was coming on, and no direct attack could be made upon the city of Tripoli for six months to come. The capture of the Philadelphia, and the necessity of keeping the Argus at Gibraltar to watch the Moors and guard the straits, left a working force of one brig and three schooners, beside the flagship. The Argus was the best of the smaller vessels, and her absence weakened the force seriously. The Philadelphia was in the enemy's hands, in almost as good condition as before the accident. The city of Tripoli was amply protected by its batteries, mounting over one hundred heavy guns, and by a flotilla. The approaches to the city were intricate and dangerous,

and the Tripolitans knew every shoal and hidden rock and winding passage, while the charts used by our ships were incomplete and inaccurate. The officers of the squadron were men of comparatively little experience, and nearly all unknown to Preble before they reported to him for this service. To bring this force to the highest state of efficiency, and then to carry it into action with the smallest risk and the best results, was now Preble's task. Evidently it called for the exercise of faculties quite different from those which won the victories of the former wars—a power of combination, a clear judgment, a faculty of rapid organization, a wise foresight, and that keen perception of individual character, which enables a man to choose the best men for the work, and to find some kind of useful work for everybody. It needed an active organizer, a prudent but resolute commander, and an exacting disciplinarian: a man who left no loose threads about his own work, and who would not allow them in the work of any one else.

Preble was on the alert from the first. He fixed his rendezvous at Syracuse, on the 1st of December, and immediately set on foot arrangements to carry on a secret correspondence with Bainbridge, which was kept up through the year, with great advantage to the squadron. He sent an agent to Malta, to act with Pulis, the United States Consul at that place, in forwarding supplies and provisions to Bainbridge. On the 10th of December he wrote to Pulis from Syracuse.

*Commodore Preble to Consul Pulis.*

"U. S. FRIGATE CONSTITUTION,
SYRACUSE HARBOR, Dec. 10, 1803.

"I have received your letter of the 26th Nov., by Lieut. Dent.

"You have done right in sending Captain Bainbridge three hundred dollars, for himself, officers, and crew, and if it had been three thousand dollars, I should be answerable for the supply. You have done right in sending the medicines he required.

"I expect soon to be at Malta, and will then settle the business between you and Mr. Higgins, by ordering all the provisions and stores to be shipped for this place.

"I shall sail from this place tomorrow for the coast of Tripoli, where I have now some vessels cruising. You will perceive by the enclosed that Tripoli is at present, and will continue to be, in a state of blockade."

The Constitution, with the Enterprise in company, sailed soon afterwards for Tripoli, to reconnoitre. On the way back, about Christmas, the Enterprise captured a Tripolitan ketch, called the Mastico. She

had previously been a French gunboat, and Preble took her into the service as a tender, and named her the Intrepid. Meantime the other vessels arrived at Syracuse, and Preble, after giving orders and making arrangements that would keep every body busy during his absence, sailed in the Vixen to Malta, to send letters and stores to Bainbridge. Among his papers is a letter to Bainbridge, written during this stay at Malta.

*To Captain William Bainbridge.*

"MALTA, Jan. 23, 1804.

"You will receive a present supply of money from here through the British Consul, B. Mc Donough, Esq., forwarded by Mr. Higgins.

"Any letters you will direct to the care of William Higgins, Esq., whom I have appointed Agent at this port for the squadron of the United States in these seas, and I am confident that he will pay you every attention. The clothing and other stores which ought to have been with you six weeks since, were detained by Mr. Pulis; and for what reason I know not. Your drafts on Mr. Higgins will be duly honored. Keep up your spirits, and despair not; recollect there's a sweet little cherub that sits up aloft.

"May the Almighty Disposer of all events aid me in my plans and operations for the good of my country, and may you be liberated by them is the hope of

"Your friend who esteems you,

EDWARD PREBLE."

Preble returned to Syracuse about the end of January. By this time he had fully arranged a plan for the destruction of the Philadelphia. Whether the project originated with him or with Bainbridge, Decatur, or Stewart, is not of much consequence. It was a subject, doubtless, about which every one in the squadron had thought and talked in the two months during which they had been lying in port. Bainbridge suggested it in a letter written in December, and Decatur before this had volunteered for the expedition. Afterwards Stewart, the Lieutenant in command of the Siren, offered to go in, but Preble had already promised the first volunteer.

Decatur was at this time twenty-four years old, and had been only five years in the service. His father, Captain Stephen Decatur, was the commander of the Delaware during the French War, when she took the Croyable, the first capture of the war. His son had been studying at the University of Pennsylvania, and had afterwards gone into a

counting house; but his eagerness to enter the Navy led Commodore Barry to get him a warrant as midshipman in 1798, when the United States was fitting for sea at Philadelphia. When he joined the ship, he was nineteen years old, and without any sea-training whatever. In his cruise in the West Indies, he made such progress, that he was promoted to Lieutenant the next year. All the good opportunities of the French war fell to Truxtun, and Barry's cruise was without any striking events. It was perhaps as well for Decatur, who had so much to learn of the routine of his profession, that he should have had this uninterrupted cruise for study and practice with so good a master. He made such good use of his time that two years after, when the Essex was fitting out for a cruise in Dale's squadron, Bainbridge chose him as First Lieutenant. Dale returned in December, 1801, and in March, 1802, Decatur sailed as First Lieutenant of the New York, under Captain James Barron, in Morris's squadron. Next year he came home, and after two month's respite, he took command of the Argus, and brought her out to the Mediterranean to join Preble. On his arrival he took command of the Enterprise, exchanging with Hull, who was his senior. Though he had only had five years in the Navy, they were years of almost uninterrupted sea-service, under the best captains.

Commodore Preble returned from Malta about the 1st of February, and Decatur received his orders on the 3rd, to proceed to the harbor of Tripoli. He was to take the Intrepid, with seventy-five officers and men of his own selection, and the Siren was to go with him to support and cover his retreat. Decatur made his choice of men from his schooner, the Enterprise, all on board volunteering for the expedition. He took all his lieutenants, Lawrence, Joseph Bainbridge, a younger brother of Captain Bainbridge, and Thorn; and one midshipman, Macdonough. Five midshipmen were selected by Commodore Preble to go with him; among them Izard and Charles Morris. Decatur's preparations were made in a few hours, and on the evening of the day on which the orders were issued, the Intrepid and Siren sailed for Tripoli.

After a voyage of four days, they arrived in sight of the city; but a storm came up and kept them off a week longer. On the afternoon of the 16th, they came once more in sight of Tripoli, and the wind being light and favoring, Decatur made up his mind to attack that night. The boats of the Siren were to join him, but the brig stood off to keep out of sight, and her boats did not come up in time; or rather, Decatur, fearing delay, was unwilling to wait for them, and prepared to make the attack alone.

The Philadelphia was lying in the inner harbor, close to the batteries on the castle, the molehead and the New Fort, and within easy range of all the other batteries of the harbor. She mounted 40 guns, which were kept loaded, and a full complement of men was on board to serve them. Close by, between her and the shore, lay three Tripolitan cruisers and twenty gunboats and galleys, all of them fully manned and in readiness. To attack this force, Decatur had a ketch of sixty tons, mounting four small guns, and with a crew of seventy men.

About 9 o'clock, the Intrepid entered the harbor. The surf, breaking in the narrow western passage, after the gale of the last week, compelled her to take the northern entrance. There was a faint moonlight, and the view seaward was unobstructed. As the Intrepid sailed slowly in, under a light breeze, she could be seen some time before she reached the frigate. The crew lay hidden under the bulwarks. Only two or three officers were to be seen on deck, Decatur and the pilot standing by the helm. When the ketch had come within thirty yards of the Philadelphia, she was hailed and ordered to keep off. Owing to her Tripolitan rig, and to the fact that her Sicilian pilot, Catalano, spoke the Tripolitan language, no suspicion was aroused by the answer that she had lost her anchors in the gale, and the request to be allowed to run a warp to the frigate and ride by her during the night. During the talk, lines were made fast to the bow and stern of the Philadelphia, by boats from the two vessels. The suspicions of the Tripolitan boat's crew were aroused, and, as the people of the Intrepid began to haul on the lines and the ketch came close, they suddenly gave the alarm. But, before a gun could be fired, Decatur cried "Board," and he and Morris sprang upon the deck of the Philadelphia. In an instant, sixty of the officers and crew of the Intrepid followed, climbing over the rail, and through the ports and gangway, wherever they could. The Tripolitan crew were panic-struck for the moment, and gathered on the forecastle. Decatur waited coolly until he had got all his men together, and formed them,—it took but a moment,—and then, at their head, he made for the enemy. The struggle was short and decisive. Those who resisted were cut down, and the rest jumped overboard precipitately. The attacking party at once separated and went below to the stations which had been assigned them, carrying everything before them. About twenty of the enemy were killed. In five minutes, Decatur found himself in complete possession of the frigate, without a man killed, and only one slightly wounded.

The temptation to try to bring the Philadelphia out must have been

strong, but Preble's orders on the subject were explicit. She was set on fire in half a dozen places at once; and the Americans, only waiting until they could see that the work was thoroughly done, returned to the Intrepid, and shoved off from the burning ship. There was no time to be lost. Though no shots had been fired in the engagement, yet the alarm had been given, and many boats put out from the shore and from the Tripolitan vessels. In their uncertainty and hesitation, they were slow in forming for an attack. With the help of the sweeps and a slight land breeze that had sprung up, the Intrepid got away from the boats and the burning frigate, the neighborhood of which was becoming dangerous. She was now a mass of flames and the magazine must explode in a moment. The bright light showed exactly the position of the ketch, and all the shore batteries opened fire upon her. Presently the Philadelphia drifted in towards the castle, with her broadside towards the town, and, as her, guns loaded and double-shotted, became heated, they discharged their contents among the enemy. The Intrepid received one shot in her top-gallant sail, but was otherwise uninjured. Presently she met the boats of the Siren, and in a few moments more the Philadelphia blew up.

When the news of Decatur's exploit reached home, he was immediately promoted; and thus he had the extraordinary honor, which has fallen to the lot of no officer of our navy before or since, of being a full captain at the age of twenty-five.

During the rest of the winter, and the whole of the spring, the Commodore was busily occupied in preparing for the operations he was planning for the summer. The blockade was kept up with great strictness, notwithstanding the severe weather, which lasted most of the season. The Commodore was at Syracuse, Tunis, Tripoli, Malta, Messina, Naples, as occasion called him, but never long in any one place. His longest stay was at Naples, in May, where he was engaged for ten days in negotiating for gunboats. At the end of this time he left for Messina with an order from the King of the Two Sicilies for six gunboats and two bomb-vessels or mortar-boats. These were taken at once to Syracuse, and prepared for service. The gunboats were vessels of twenty-five tons, and carried a long iron 24-pounder in the bow, with a complement of thirty-five men. The mortar-boats, of about thirty tons, carried a 13-inch brass mortar, and forty men. All the boats were officered and manned from the squadron, except twelve Neapolitan bombardiers, gunners and sailors, who were attached to each vessel, by permission

of their government. This was made necessary by the fact that every vessel in the squadron was short of her complement. The gunboats were built for harbor defence, and were flat bottomed and heavy, so that they did not sail or row even tolerably well. They were not intended to go to sea, and could not be navigated with safety, unless assisted by tow-ropes from the larger vessels, and not even then, in very bad weather. "However," said Preble, in his report to the Department, "as they were the best I could obtain, I have thought it for the good of our service to employ them, particularly as the weather in July and August is generally pleasant, and, without them, my force too small to make any impression on Tripoli."*

In June, while the squadron was preparing, Commodore Preble made an effort to negotiate with the Pasha of Tripoli, but with no satisfactory result; and, soon after, he was called away to Tunis, to quiet some angry demonstrations in that quarter. A Tunisian vessel had been seized in a suspected attempt to break the blockade of Tripoli, but had subsequently been released, with a warning. The Bey had heard of the seizure, and, ignorant of the recognized laws of blockade, made threatening demands for reparation. The presence of a squadron in his harbor had the desired effect, and Preble, returning to Syracuse, was at last free to give his undivided attention to the reduction of Tripoli.† On the 21st of July, the ships left Malta, and on the 25th they came in sight of Tripoli, and were joined by the blockading vessels.

*Am. St. Papers, Nav. Aff., 1. 133.

† The natme of the questions arising during Preble's command, and his manner of dealing with them, are illustrated in the following letters:—

*To G. Davis, Esq,. Chargé d'Affaires of the United States at Tunis.*

"CONSTITUTION, MALTA.

July 18, 1804.

"I am honored with your favor of the 23d ult. The present situation of our affairs renders it impossible for me to suffer any vessel to proceed to Tripoli, particularly as I sail this day with bomb and gun-vessels to attack that place. I have therefore advised the master of the Spanish vessel to return to Tunis, particularly as I understand she has articles on board for our worst of enemies, *the Spanish carpenters*, who are *building gun-boats for the Pasha*.

"I will endeavor to retain and destroy the passport you mention.

"I have not the time to write Colonel Lear at this moment, but shall as soon as I return, and send a vessel down to carry the letters, and shall order her to touch at Tunis for yours."

The squadron now consisted of the frigate Constitution, the brigs Argus, Siren, and Scourge, (the last of which was a captured blockade-runner,) the schooners Nautilus, Vixen, and Enterprise; six gunboats, and two bomb-vessels or mortar-boats.

The gunboats were arranged in two divisions, and commanded as follows:—

First Division.—No. 1, Captain Richard Somers; No. 2, Lieutenant James Decatur; No. 3, Lieutenant Joshua Blake.

Second Division.—No. 4, Captain Stephen Decatur; No. 5, Lieutenant Joseph Bainbridge; No. 6, Lieutenant John Trippe.

The mortar-boats were commanded by Lieutenant John H. Dent, and Lieutenant Robinson.

From the time of Commodore Preble's arrival, on the 25th of July, until the 10th of September, when he was relieved of the command, Tripoli was closely pressed by the whole force of the United States in those waters. Attacks followed each other in rapid succession, whenever the treacherous weather would permit, and every measure was resorted to that could harass or annoy the enemy. In addition to the batteries, the harbor was now defended by nineteen gunboats, two galleys, two schooners of eight guns each, and a 10-gun brig, ranged in order of battle, at secure moorings, inside the long range of rocks and shoals, which extended, in an easterly direction, for two miles. These rocks covered the harbor on the northern side, and protected it from the northerly gales, which blow incessantly on this coast. The blockading squadron lay in an exposed position, to the north of the rocks, and the shoals prevented the Constitution from approaching near enough to the gunboats to destroy them. The channels were winding and dangerous, and the enemy had every advantage in his familiarity

*To Josef Noguera, Consul-General of Spain to the Regency of Tunis.*

"U. S. S. Constitution,
Malta, July 18, 1804.

"I am honored with your letter of the 24th ult., and have to inform you that the critical situation of our affairs with Tripoli, at the present moment, renders it impossible for me consistently with prudence to permit the Courier, St. Fernando, to proceed to Tripoli. I have therefore warned the Master of that vessel not to attempt it, particularly as he has in charge articles for our enemies, *the Spanish subjects who are building gunboats for the Pasha of Tripoli.*

"The Spanish vessel, Captain Torres, has been liberated agreeable to the information given you by Mr. Davis, notwithstanding the violation of her passport, but no indulgence of the same nature will again take place."

with the ground. Under such circumstances, any imprudence would have been fatal to the squadron.

For the first week, continued gales from the north and north-east prevented an attack. Every thing was in readiness, but there was no choice but to wait. By the third of August, the weather had moderated, and the squadron stood in for the town. The gunboats and bombs were still in tow of the larger vessels. Early in the afternoon of this day, as the squadron approached the town, it was noticed that the Tripolitan gunboats had ventured outside the rocks. Under these favorable circumstances, the Commodore determined to make an attack. The gunboats and bombs were cast off, and at a quarter before three the bombs began the action by throwing shells into the town. The wind was from the east, and the enemy's gunboats were arranged in three divisions. The eastern or van division, of nine boats, lay outside the line of rocks. The centre, of seven boats, lay within the rocks, as a reserve. The western division, of five boats, was directly under the western batteries.

The American flotilla, of six gunboats, advanced gallantly to attack the Tripolitans, more than three times their number. Their object was to get to windward of the enemy, and make a concentrated attack on the first division. Captain Somers, in No. 1, failed in his purpose, owing to the bad sailing of his boat, and, falling off to leeward, engaged single-handed the enemy's rear. The force of his attack drove the five boats to take refuge within the rocks, after the loss of many of their men. Lieutenant James Decatur, in No. 2, engaged one of the enemy's van, and forced it to surrender; but, as he was stepping on board of the prize to take possession, he was treacherously shot, and fell, mortally wounded.* The officer second in command of the boat then hauled off. Lieutenant Blake, in No. 3, failed to close with the enemy, but, taking a position to windward, kept up a fire from a distance.†

Of the second division, Capt. Decatur, in No. 4, carried two of the

* Cooper gives it as his opinion that the Tripolitan gunboat had not struck, but quotes no authority to sustain his view. The statement in the text is based on that in the journal of Commodore Preble, which is repeated in his official report to the Navy Department. Am. State Papers, Nav. Aff., 1, 134.

† According to Cooper, it appeared at a court of inquiry, held some time afterward, that Blake only obeyed a signal of recall, which was shown for a moment, by mistake, from the flagship. I have not been able to find any

Tripolitan gunboats, in quick succession, by boarding, after severe and bloody conflicts. The slaughter in these two hand-to-hand fights was so great that, out of sixty officers and men on board the Tripolitans, thirty-three men were killed outright, and the rest made prisoners; nineteen of them being badly wounded. The fury of our men carried everything before them, yet the wounds of the Captain and three men were the only injuries they suffered.

No. 5, under Lieutenant Bainbridge, had her lateen yard shot away early in the action, and so was prevented from making any captures; but she kept up a steady fire upon the enemy, and, upon their retreat, pursued them close upon the rocks. Lieutenant Trippe, in No. 6, also attacking the windward division of the enemy, ran alongside a large boat and boarded her, with Midshipman Henley and nine men, but his own boat fell off before more could get over. The Tripolitan had

record of the court. The following letter, found among the Preble papers, will throw some light upon the Commodore's view of the case.

*To Lieutenant Blake.*

"PORTLAND, Sept. 6, 1806.

"SIR: Being on a tour to the eastward, from which I arrived last evening, it has not been in my power until now, to acknowledge the receipt of your letter of the 29th ult. I have ever entertained too great a regard for your character to have mentioned your conduct to your friends in any other way but that of candor.

"Captain Somers, who commanded the division to which you were attached on the 3d of August, made his report to me after the attack, and in my despatch to the Secretary I extracted from that report the very mildest part. Had I published the whole, or communicated it to the Secretary, it would have influenced the public mind, as well as the Secretary's, much against you. I merely observed that No. 3 was to windward (that is, of Capt. Somers), firing at the batteries and gunboats in the harbor. Of course I placed you in action with the rest of the squadron, and although I observed that had you gone to the assistance of Capt. Somers, some of the enemy's boats might have been captured in that quarter, still, I did not infer but that you were as usefully employed as the other vessels of the squadron. However your feelings may have been affected on reading my despatch to the Secretary, you may rest assured that I never felt myself disposed to injure your reputation or do any kind of injustice. On the contrary, it would afford me pleasure, at any time, should it be in my power, to render you acceptable services.

* * * * * * *

"Your motives for demanding a court of inquiry were undoubtedly correct.

"I am, with esteem, Sir, your most obedient servant,

EDWARD PREBLE."

thirty-six men on board, and the boarding party of eleven found themselves on the deck of a hostile boat opposed to more than three times their number. It was a perilous moment, but a moment which gave them no time for seeing the apparent hopelessness of the combat. In an instant they were engaged in a pell-mell fight, and, almost before they knew it, fourteen of the enemy were lying dead, and the rest, twenty-two in number, had surrendered. This astonishing result was brought about by the sheer pluck and fighting power of the boarders. Trippe, the commander, received eleven sabre wounds, and three of his men were wounded; but, beside these, no one was hurt.

Meanwhile, a constant fire was kept up from the ships and mortar-boats, upon the town, the batteries, and the reserve division of the enemy's gunboats. Twice they attempted to come out, and, joined by the others which had been defeated by Somers, to rally and renew the contest; but, each time, they were covered and checked by the fire of the Constitution. Three of them were sunk in this way, and the decks of many of them were cleared. Several times the batteries were silenced, and many shells were exploded in the town.

At half-past four, the wind came round to the north, and made it dangerous to remain near the shore. The bombs and gunboats were signalled to retire from action. The wind freshened from the north-east, and the Constitution tacked, and fired two broadsides in stays, which drove the Tripolitans out of the castle and brought down the minaret of a mosque. The larger vessels took the gunboats and their prizes in tow, and at five o'clock the squadron was brought to, two miles from the batteries. Lieutenant James Decatur was brought on board the Constitution, and died in a few moments after he reached the ship. Of all the officers and men engaged in this bloody conflict, he was the only one killed on the American side. Thirteen * others were wounded. Thus ended the first attack on Tripoli,—an attack in which the best results had been accomplished at the smallest cost of life.

The next movement was made on the 7th, the intervening three days being taken up with repairs. The prizes taken on the 3d, had increased the number of gunboats to nine, and some changes had been made in the officers of the first six. The three new gunboats were commanded as follows:—No. 7, Lieutenant William M. Crane; No. 8, Lieutenant Jonathan Thorn; No. 9, Lieutenant James R. Caldwell, with Midshipman John S. Dorsey, and Midshipman Robert T. Spence.

* The journal says twelve; but this does not include one marine on board the Constitution, whose arm was shot away.

The bombs were ordered to take their position in a bay to the westward and throw shells into the city; while the gunboats were to silence a 7-gun battery which commanded the entrance to the bay. At nine in the morning, the Constitution was at anchor six miles from the city. The other vessels lay three miles within her. It was nearly calm, but with a strong current setting in to the eastward. The gunboats and bombs advanced slowly to the attack with sails and oars. The Constitution had her topsails and topgallant sails set ready for the first breeze; and at half-past one, when a light wind sprang up from the north-east, she weighed and stood in. As the wind was on shore, it was imprudent for any of the larger vessels to join in the attack: for, if a mast were shot away, the loss of the ship would probably follow. At half-past two, the signal was made for the gunboats and bombs to begin the attack, and they at once opened a heavy fire upon the town and batteries. In the course of two hours, the 7-gun battery, with the exception of one gun, was silenced, and the walls were almost wholly destroyed. The bombs threw about fifty shells into the town, and, though in an exposed and dangerous position, suffered no loss in men.

The enemy's gunboats and galleys were all in motion under the batteries, apparently with the intention of attacking our flotilla; but the Constitution, Nautilus and Enterprise were to windward, ready to cut them off from the harbor, if they should venture out; while the Siren and Vixen remained to leeward, to support and cover any of our boats that might be disabled. The enemy thought it best to remain within the rocks.

At half-past three, one of the prize gunboats, No. 9, was blown up by a hot shot which passed through her magazine, and immediately sank. The explosion killed Lieutenant Caldwell, the commander, Midshipman Dorsey, and eight petty officers and men. Midshipman Spence and the rest of the crew were picked up unhurt. Spence had charge of the gun which the crew were loading at the moment the boat was struck, and, though they saw she was sinking, the gun was loaded, the men gave three cheers, and fired, just as the boat went down.*

At half-past five, the wind freshened from the N.N.E., and all the boats were signalled to retire from the action. The total loss in the engagement was twelve killed, and six wounded; but among them were two of the most promising and valuable officers in the squadron. The gunboats were somewhat cut up, but no serious damage was felt except

* Commodore Preble's official report. Goldsborough, Naval Chronicle, 227.

in the loss of No. 9. Five hundred 24-pound shot had been thrown into the town, which told severely on the houses and forts.

During the engagement, a strange sail had been seen to the northward, and the Argus was sent in chase. It proved to be the John Adams, Captain Chauncey, from the United States. She was the first of the new squadron. The re-enforcement, so much needed, and so long asked for by Commodore Preble, was now on the way, but not in the form he had hoped. The government had at last decided to send out an overwhelming force. As only two captains junior to Preble were in the United States, and as the law required an officer of this grade for the command of a frigate, the Department had no choice but to supersede him. The John Adams brought despatches from the Secretary, approving his conduct of his command, and expressing the thanks of the President. But these compliments, however grateful, could hardly soothe the wounded feelings of the disappointed commander. In his private journal, kept in his own hand in the solitude of his cabin, and meant only for his own eye, after the account of the battle, and the arrival of Chauncey, we find this painful entry: "How much my feelings are lacerated, by this supersedure at the moment of victory, cannot be described, and can be felt only by an officer placed in my mortifying situation." But no word of official complaint escapes him. In his despatch to the Secretary, he only regrets that the reduced size of the naval establishment deprives him of the satisfaction of subduing the Pasha, while in the chief command; and he acknowledges, with a graceful union of respect and dignity, the expression of official approval. He says: "Captain Chauncey brought me the first positive information that any re-enforcement was to be expected. By him I was honored with your letters, informing me that four frigates were coming out, under the command of Commodore Barron, who is to supersede me in the command of our naval forces in these seas; at the same time approbating my conduct, and conveying to me the thanks of the President for my services. I beg you, sir, to accept my warmest thanks for the very obliging language in which you have made these communications, and to assure the President that to merit the applause of my country is my only aim, and to receive it the highest gratification it can bestow."

The John Adams had unfortunately left her gun-carriages on board the other ships, before sailing, and the only assistance she could give was by re-enforcing the reduced crews of the other vessels. Captain Chauncey was ordered to remain with the squadron, and, at all the later

engagements, he came on board the Constitution with a large detachment of men.

On the 9th, a proposal came from the Pasha through the French Consul, to treat for peace, the ransom of the American prisoners being fixed at one hundred and fifty thousand dollars. These were the only conditions offered. The terms of the last negotiation, made before the action of the 3rd of August, had been fixed by the Pasha at half a million; and this enormous reduction in his demands had been solely due to Preble's operations. Nevertheless, the offer was rejected.

Commodore Preble now decided to renew the attack without waiting for the expected squadron. Ten days of bad weather kept the vessels away from the coast, and the plan was postponed from day to day. Meanwhile, Captain Decatur and Captain Chauncey had taken advantage of a favorable night to reconnoitre the harbor, and find out the arrangement of the enemy's flotilla at night. They rowed in two small boats to the western rocks, and found the Tripolitan gunboats anchored in a line abreast from the mole to the Pasha's castle, with their heads to the eastward. Having obtained the necessary information, the Commodore planned a night attack, and on the 24th, at eight o'clock in the evening, the squadron stood in for the town. At midnight it fell calm, and the ships remained outside, while the gunboats went in with the bombs in tow. The bombardment began at two o'clock, and lasted till daylight, when the boats were drawn off.

For the next four days the weather prevented any operations, but on the night of the 28th, the attack was repeated with better success. This time the bombs were not in a condition to be brought into action, and they remained with the John Adams, Scourge, and transports, at anchor, seven miles from the town. The Constitution was anchored two miles to the north-east of Fort English, and the light vessels and gunboats were ordered to take their position close to the rocks, at the entrance of the harbor, within grape-shot distance of the Pasha's castle. All the boats in the squadron were officered and manned, and attached to the gunboats. At three in the morning, the boats anchored with springs on, within pistol shot of the rocks, and began a brisk fire upon the town, forts, and shipping. This was kept up till daylight. By this time the ammunition on board the boats was nearly exhausted, and the Constitution weighed and stood in to the harbor, at the same time signalling to the brigs and schooners to take the gunboats in tow, and withdraw from the action. The frigate opened fire on the enemy's gunboats, which were engaged with our fleet, and, by

sinking one and disabling two others, caused them all to retreat to the mole. When she came within musket shot of the mole battery, she brought to, and for nearly an hour poured a steady fire of round-shot, grape, and canister into the town, the castle, and the batteries. The castle and two of the batteries were silenced, and a Tunisian vessel was sunk in the mole. Shortly after 6 A. M., the Constitution hauled off.

During this action the ships suffered only in their sails and rigging, and that not to any serious extent. Not a man was hurt on board the Constitution. A boat belonging to the John Adams was sunk by a double-headed shot, and three men were killed. This was the only loss on the American side. On the other hand, the bombardment did great damage in the town. According to the account of the master of a Spanish vessel that came out of the harbor a few days later, the loss of life and the destruction of property were greater than at any time before.

The next attack was made on the 3d of September. It was the fifth regular demonstration made against Tripoli by Commodore Preble, and the last in which the squadron took part. At two o'clock in the afternoon, the wind being from the eastward, and the squadron lying two and one half miles to the N.N.E., the Tripolitan gunboats were seen working up against the wind in the eastern part of the harbor. The object of this manœuvre was to keep to windward of our gunboats, in case they entered the harbor to attack the town. By this time, the Tripolitans understood Commodore Preble's tactics so well that they were nearly certain what to expect in any given state of the wind and current, and they prepared themselves accordingly. Their manœuvre in this case was so far successful that our gunboats were obliged to engage them to windward, while only the bombs were able to take a posi-from which they could shell the town. The bombs reached their station at half-past three, and opened fire. As our gunboats approached, firing upon the Tripolitan flotilla, the later took refuge behind the reef of rocks under cover of the forts on this side of the harbor. Near Fort English and a little to the westward, an earthwork had lately been thrown up by the American prisoners, working under compulsion. The two batteries mounted together fourteen guns, and their fire was now brought to bear upon the American gunboats.

Presently the Siren, the Argus, and the other light vessels came up, and the action was divided. One division of the gunboats, together with the men-of-war, attacked the forts, while the other division pressed the flotilla. Meanwhile, the bombs kept up the bombardment of the

city, though exposed to a continuous circle of fire from all the batteries of the inner harbor. Seeing their unprotected situation, Commodore Preble ran down in the Constitution, and brought to, within the bombs, to divert the enemy. In this position, he fired eleven broadsides, which silenced one of the batteries, and did much damage to the town and fortifications.

The action had lasted about an hour, when the wind increased and came round to the northward. It was imprudent to remain in position longer, and signal was made to retire. Fifty shells had been thrown into the town, and four hundred shot were fired by the boats. On the American side there was no loss of men, and the vessels, as usual, were only slightly injured. The Tripolitans were more expert in tactics than in gunnery.

Dissatisfied with the results of his year of preparation, and his four weeks of active work, Commodore Preble was eager to take some more destructive measures against the enemy. With this view, he had arranged a plan of converting the Intrepid into a fire-ship, or floating magazine, and sending her in to explode among the Tripolitans. Accordingly, about one hundred barrels of powder were stowed in her magazine, and fixed shells were placed in different parts of the vessel. The magazine was to be fired by a fuse, calculated to burn fifteen minutes. Richard Somers, the Captain of the Nautilus, who had commanded one division of the gunboats during the whole series of operations before Tripoli, had volunteered for the dangerous service, and was put in charge of the Intrepid. He had with him Lieutenant Henry Wadsworth, of the Constitution. Lieutenant Joseph Israel, also of the Constitution, who had assisted the two other officers in the preparation of the Intrepid, was allowed to go at his own earnest request. They took with them two boats, one from the Nautilus, with four men, the other from the Constitution, with six men.

On the evening of the 4th of September, the day after the last engagement, everything was ready, and the Intrepid got under way and stood for the western entrance of the harbor. The Argus, Siren, and Nautilus went with her as far as the rocks, and remained there to pick up the boats on their return. Though the night was thick and there was only a faint starlight, the Intrepid was sighted from the Tripolitan batteries, between the mole and the point of rocks, and they at once opened fire upon her. She went on her course towards the mole, where the enemy's gunboats were at anchor, and in a few minutes was out of sight of the other vessels. Suddenly, before the time allowed had pass-

ed, before she could possibly have reached her destination, the explosion took place. There was a quick flash, a sheet of flame, a report; then the sound of bursting shells, and cries of alarm from the city; and then—silence.

What happened on board the Intrepid has, from that day to this, been a matter of conjecture. The three ships remained for hours off the western passage, but saw no signs of returning boats or men. The Tripolitan batteries ceased firing at once, but this appears to have been rather from panic than from any injury they received. Thirteen bodies drifted ashore in the course of the next day, and Captain Bainbridge was taken to see them, but they were all so burnt and disfigured as to be unrecognizable. There can be no doubt that they were those of the officers and crew of the Intrepid. As far as is known, no Tripolitans were killed by the explosion.

It was supposed by Commodore Preble, that the Intrepid was attacked by one or more of the enemy's gunboats, and that, as they were in the act of boarding, Somers set fire to the powder, and blew himself and his enemies up together. His conjecture was founded upon a resolution made by the three officers before setting out, not to allow themselves or their vessel to be taken by the enemy. The Tripolitans were much in want of powder, and Somers had declared that, if he was boarded by an overwhelming force, he would fire the magazine. But, though Somers and the officers with him were quite capable of such an act of self-devotion, it seems to be at least equally likely, that the Intrepid was exploded by a shot from the batteries,—as happened to one of the gunboats in the action of the 7th of August, when Caldwell and Dorsey were killed. It appeared to Commodore Preble the next morning, that one of the enemy's gunboats was missing, and that three more were disabled and drawn on shore; but it is possible that in this he was mistaken. No certain account was ever given by the Tripolitans of the events of the night, and, to this day, it is unknown whether any injury was inflicted on the enemy.

With this melancholy event Preble's operations came to a close. The bad season was upon him, when attacks were impossible, and even blockading dangerous and difficult. The Constitution and two of the small ships remained off Tripoli, and the rest of the squadron was sent into port. On the 10th of September, the President, Commodore Barron's flag-ship, and the Constellation, appeared in sight, and Preble gave up his command.

Commodore Barron found his task to all intents accomplished before

his arrival. For the moment, indeed, nothing could be done: at this season, Tripoli was secure from the attacks of an enemy, behind her barriers of rocks and shoals; and any attempt would probably have been followed by the loss of some of the frigates. But the real work was already done. The Tripolitans had already lowered their terms under the stress of Preble's attacks; and in the presence of a force so much more effective, they might be expected to agree to anything. When Rodgers, whom Barron's illness placed in command, arrived before Tripoli in the following spring, our Mediterranean fleet consisted of six frigates, two brigs, three schooners, a sloop, two mortar-boats, and ten gunboats. There was no fighting to be done.* The negotiations lasted a week, and were conducted on board the flagship; and, on the 3d of June, the treaty was signed, and Bainbridge and his companions set at liberty.

In looking back at the events of the war with Tripoli, we are compelled to give the highest credit to the services of Preble. Others were distinguished by successful exploits which did serious harm to the enemy, as in the burning of the Philadelphia by Decatur, and, in the earlier period, the destruction of a large cruiser and the capture of the Meshuda by Rodgers, and the victory over the polacca, Tripoli, by Sterrett,—but with Preble rested the conduct of those operations that brought Tripoli to terms. The powerful squadron of 1805 had a direct influence in bringing about the treaty; but the attacks of the summer before had spared it the necessity of fighting. Of all the squadrons sent to the Mediterranean, that which Preble led against Tripoli was the least adequate to the purpose. A single frigate, supported by five brigs and schooners whose guns were too light to tell much on solid walls of masonry, and eight unseaworthy gunboats and mortar-boats, was a slight force to bring against a strongly-fortified town, filled with troops, and protected by a circle of heavy batteries and a large flotilla. Moreover the perils of the harbor, with incessant northerly gales outside, and fatal rocks and shoals within, its difficult entrance, and its unknown and tortuous channels, made a sudden attack or coup-de-main impossible. Indeed, at this day, with the full and accurate charts of

* Gen. Eaton's expedition with Hamet Pasha, which resulted in the capitulation of Derne, doubtless had some influence in bringing the Pasha of Tripoli to terms; though it is difficult to see how he could have acted otherwise, if Eaton's expedition had never been undertaken, in view of the overwhelming naval force.

the British survey, navigators are forbidden to enter Tripoli without a pilot.

Preble's success in inspiring the enemy with a fear of America was partly due to the officers under him. The foremost of these was Stephen Decatur. Every attempt of Decatur's met with success, and was carried out with a dash and brilliancy that delighted and dazzled people. He was a man of greater personal attractions than Preble, and his exploits appealed more to the imagination, so that he became the popular hero of the war.

His comrades were not unworthy of him, nor of their commander. Doubtless the lapse of seventy years adds something to the lustre of our naval heroes of the past; but there was gathered at Tripoli, in 1804, a body of officers that it would be hard to surpass in later history. There was Macdonough, who won the victory of Lake Champlain; Lawrence, the commander of the Chesapeake; Hull, who, in 1812, carried the Constitution away from a British squadron, and a month afterwards captured one of his late pursuers; Stewart, the captor of the Cyane and the Levant; Blakely, who sunk the Avon; and Chauncey, the commander on Lake Ontario. Among the younger officers, there were Spence and Henley, Charles Morris and the younger Bainbridge. They fought for no unworthy object,—the abolition of piracy in the Mediterranean, and the liberation of their brother officers. These officers themselves,—Bainbridge, Porter, Jones, and Biddle, were among the foremost who won distinction in the War of 1812. Among the great names of this war, there is only one that we miss in Preble's squadron. To Perry alone is a place wanting in this company of illustrious men. He was condemned to inaction in the squadron of Morris the year before, and he returned with Barron to see the close of the contest; but the opportunity that would have called forth all his talents and all his energies was denied him by fortune.

Of those whose lives were sacrificed to secure this great result, but one word remains to be said,—a word not to be lightly spoken. Others perhaps were as brave, others as ready to give their lives for their country; but these only were called to make the sacrifice. And one thing is to be noticed,—they were all young men; hardly one of them more than five and twenty. To the enthusiasm and ready obedience of boys, they joined the courage, and earnestness, and self-reliance of men. Decatur, killed in a hand-to-hand fight with the Turks; Caldwell and Dorsey, blown up in the heat of an action; Somers, after leading his gunboats with the same coolness and gallantry through six successive

engagements,—Somers, and his devoted companions, Wadsworth and Israel, who volunteered for an enterprise whose danger they well understood,—all perished in the very flower of their early manhood. And nowhere more than among the younger officers of the Navy of to-day should their memory be kept fresh and bright, and the impulses which moved them be felt in all their strength and fulness. It is for this, that upon the ground of the Academy, at Annapolis, stands a monument in their honor; that not a day passes in which the young officers who are in training there, fail to look upon the memorial of their heroism and sacrifice. It stands there for them, that there may be always before them a bright example of the virtues that form the high character of a naval officer,—the virtues of obedience and courage, of self-control and self-devotion. And, if there are those in the service now, who are prone to murmur against the old Navy, to forget all that was generous and gallant in the service of other days, and to make light of the records and traditions of a glorious past, let them at least hold in reverence and honor the names of the officers who fell before Tripoli.

## JOURNAL BEFORE TRIPOLI.

TUESDAY, 24th July, 1804.

Light airs from the westward. Squadron in company. At 10 P.M., fresh breezes from S.E., which soon changed to S.W.

A. M. Ordered all the water-casks on board the gunboats and bomb-vessels to be filled from this ship. It is a necessary precaution in case of separation, as they carry only six days' allowance of that article.

At noon, Tripoli bore S.W. by S., sixty miles.

WEDNESDAY, July 25, 1804.

Wind E.N.E. We completed watering the bombs and gunboats. At 2 A. M., fell in with the Siren. At 4, saw the Argus and Enterprise. At 6 A. M., wore ship off shore, with the wind S.E., a heavy sea heaving on the coast. Tripoli in sight, bearing by compass S.W., distant 15 miles. At 8, the Argus and Enterprise joined company. Made the following disposition for towing gunboats and bombs, viz.,—Constitution, the two bombs; Argus, Nos. 2 and 3, gunboats; Siren, No. 5; Vixen, No. 6; Nautilus, No. 1; Enterprise, No. 4. With this arrangement, I presume that we shall be able to tow them off shore in case of a norther.

Made signal for all captains, and delivered them the orders of sailing. Lat. obs., 33° 10′ N.

THURSDAY, 26th July, 1804.

Wind N.N.E. to N.E., and a heavy sea setting on shore, which makes it imprudent to approach near the coast. Tripoli bears S.S.W., about five leagues. At 5 P. M., saw the Scourge in the S.W. We stood to the eastward by the wind all night. At 9 A. M., wore and bore up to the W.S.W. The Siren joined company. Our squadron now consists of one frigate, three brigs, and three schooners, men-of-war, two bombs, and six gunboats,—in all, fifteen sail, beside the store-ship. The whole are now in company. At noon, the squadron becalmed eight miles from the land, and about five leagues to the eastward of Tripoli, a heavy sea setting on shore. Lat. obs., 33° 7′ N.

FRIDAY, 27th July, 1804.

Wind N.E., light breezes; squadron in company. Hoisted out the large cutter; rigged and armed her. Beat to quarters to scrape and blacklead the axle-trees and trucks of the gun-carriages. Continued

to steer for Tripoli till seven o'clock, when we shortened sail and brought to, four miles from the land, Tripoli bearing by compass W. by S., about five leagues. Sounded 55 fathoms, sandy bottom. Wind E.N.E. to S.E.

All night lay with main-topsails aback, head off shore. At half past four A. M., wore and stood to the S.W. for Tripoli. Land in sight to the eastward of the town, seven or eight leagues. We have had a strong easterly current all night. At noon, wind E.N.E., Tripoli bearing S.W. ½ W., four leagues distant. A heavy swell heaving towards the land. Surgeons report 1 sick, 3 convalescent, 1 discharged from sick list. Delivered to each commander the orders for anchoring before Tripoli on our arrival off the town, viz.: the fleet to anchor in two columns, in lines parallel with the shore, which trends about east and west; the in-shore column to consist of the Argus, Constitution, Vixen, and Siren, at two cables' length asunder, the Argus to the east and Siren to the west of the line; the outer column two cables to the south, and to consist of the Nautilus to the west, Enterprise, centre, and Scourge to the east; Storeship 4 cables' length to the southward of the outer line; the Constitution to lead in and anchor first.

Saturday, 28th July, 1804.

Moderate breezes from the S.E. and pleasant. Standing in for Tripoli at 1 P. M., observed the batteries manned, an encampment of troops along the south side of the bay, and nineteen gunboats in motion, all pulling out of the harbor toward us. Three-fourths past 1, the wind shifted suddenly from the S.E. to N. At 3 P. M., we came to with the small bower in twenty fathoms' water, two and one-half miles from the shore, the round water battery in range with the Pasha's castle. The boats all under way, but the wind blowing directly on shore, and increasing, they returned into port. The squadron all came in and anchored in order, with the gunboats made fast to their stern. At 5, the wind and sea increasing so much as to make it dangerous riding, made signal for captains. They all came on board. At 6, the captains all returned to their respective ships. As it was thought prudent to get under way, made the signal to prepare. At 7 P.M., signed to weigh. At half past 7, they were all under way. At 8, we weighed and stood to the N.N.W.; wind N.E. and more moderate, but an increasing sea. At 10 P. M., several of the fleet in sight. Stood off to the N.N. W., all night. At daylight, wore and stood for Tripoli; wind E.N.E. At 11, hauled off to the northward, and brought to, to discharge the

store-ship of water and provisions, and to supply the squadron with powder, shot, and other military and naval stores. Lat. obs., 33° 3′ N.

SUNDAY, 29th July, 1804.

Wind N. E. Lying to with the squadron, discharging the store-ship. Tripoli bearing S.S.W., distant four leagues. The sea too rough to approach the town with our bombs or gun-boats. At 7 P. M., closed the squadron, Tripoli in sight, bearing S. ½ W., six leagues. Hoisted our boats in, lay to all night; wind strong from E. by S., and a very rough sea. The weather we have experienced for several days past has been uncommonly tempestuous for the season. At 5 A. M., made the signal to wear ship and bring to, the wind on the larboard tack. We wore, and 3d-reefed the topsails, wind S. E. by E. At 10 A. M., land about Tripoli in sight, S. by E., five or six leagues distant. At 11, the wind abated. Took the storeship in tow, to facilitate the discharging her cargo. Brought to with the squadron. Sent boats with officers and men, to assist furnishing the necessary supplies for the men-of-war. At noon, wind E. by S., strong breezes. Observed in Lat. 33° 9′ N. Supposed Tripoli to bear south, five leagues, but the atmosphere so close and thick that we cannot see the land.

MONDAY, 30th July, 1804.

Wind E.S.E., moderate, but a heavy swell. The boats of the squadron employed in discharging the storeship, but the sea so rough as to render our progress rather slow. Sent fuzes, clay putty, quick-match for the shells on board the bombs, and shot on board the different vessels to which the gunboats are attached. At 7 P. M., it blew a fresh gale. Cast off the storeship, and in boats. Filled away to the southward. At 8 P. M., wore with the squadron, and stood to the N.N.E., wind east, under double-reefed sails. Stood off all night. At 5 A. M., wore to the northward, and stood for the land. Wind from E. to S.E., variable. At noon, observed in lat. 33° 10′ N., Tripoli bearing S. by E., six leagues distant.

TUESDAY, July 31, 1804.

Wind E.S.E. to N.E., very variable, and a rough sea. Standing to the southward by the wind under double-reefed topsails, squadron all in sight. At 1 P. M., saw the city of Tripoli, bearing S. by E. ½ E., distant five leagues. Stood in with the wind E.S.E. until 4 P. M.; Then wore ship to the northward, Tripoli S.S.E., three leagues. At ½ past 6 P. M., the wind shifted to the N.E. by N., and blew a gale. Split our foresail and main-topsail. Sent down top-gallant yards, and

made the signal for the squadron to do the same. Unbent the split sails, and brought others to the yards. By 8 P. M., we were under a reefed foresail and close reefed main-topsail, the wind blowing very heavy, and a rough sea. From 8 P. M. to 2 A. M., the wind veered round gradually to the S.E., until it got to E. by S.; then shifted suddenly in a squall to the N.N.E. Stood to the N.W. until daylight; then wore to the S.E., and made more sail; the squadron all in sight, but much scattered. At noon, wind N.E. by E., steering S.E. by E. Lat. obs., 33° 18′ N., Tripoli bearing by calculation S.S.E. ½ E., twenty-eight miles. I ordered the foresail and main-topsail which were split last night to be ripped out of the bolt-rope, and turned in to the sailmaker as old canvas, considering them not trustworthy.

WEDNESDAY, 1st Aug. 1804.

Wind N.E. Steering by the wind on the larboard tack, all the squadron in sight. At half-past 3 P. M., Tripoli in sight bearing S. by E., the weather very unsettled and a rough sea. Wore ship to the N.N.W. At 5 P. M., made the signal for the squadron to close to prevent separation. In the night the wind moderated. At 5 A. M. wore to the S.E. At 8, sent up top-gallant yards, out large boats, and completed discharging the storeship. At noon, we observed in lat. 33° 13′ N., Tripoli bearing S.S.E., seven leagues distant. Wind E.N.E.,

THURSDAY, 2d August, 1804.

Wind E.N.E. Supplied the vessels of the squadron with a large quantity of provisions and stores. In the evening the wind came from the S.E. Stood to the E.N.E. all night. In the morning, calm. Ordered Lieut. Dent, Commander of the Scourge, with thirty of his crew, to join the two bombs, which, with the Neapolitans on board of them, completes their crews. Ordered Lieut. Wadsworth and Mr. Morris, Master of the Scourge, to join this ship, Wadsworth to do duty as Lieutenant on board, and Morris to serve in the boats.

Sent off the storeship to Malta, under convoy of the Scourge, in charge of Lieut. Izard, who is to see her safe into some port in Malta, and return to this station. The Scourge has thirty-six men on board, including officers. At noon, lat. 33° 11′ N. Discharged from the service Lewis, a seaman, and sent him to Malta in the storeship, on account of indisposition and his pleading that he was a Frenchman. Tripoli bears S. by E., distant six leagues.

FRIDAY, 3d Aug. 1804.

Wind E.S.E. to E. by N. Exercised the bomb vessels, and threw

some shells. Fresh breezes and pleasant. During the night we had fresh gales; lay to, with the ship's head to the N.E. In the morning, wore and stood for the land, Tripoli about four leagues distant, bearing S.S.W. At 8 A.M., wind E. by N. At noon, we were within two miles of the city of Tripoli, which is defended by batteries mounting sixty-seven heavy cannon pointing seaward, and twenty-two gunboats, each carrying a piece of heavy brass ordnance, besides small cannon, muskets, pistols, pikes, etc., and manned with thirty to fifty men each. They have also an armed brig, and two armed schooners in the port, full of men. I made the signal to wear and haul off, and immediately after the signal to come within hail. Cleared the ship for action, beat to quarters, and made signal to prepare for battle, intending to attack their gunboats and the city, as I observed their boats without the rocks.

SATURDAY, 4th Aug., 1804.

Wind E. by S., standing off shore on starboard tack, the signal out to come within hail. Spoke the different vessels, and acquainted their commanders that it was my intention to attack the shipping and batteries, and directed the gunboats and bombs to be prepared for immediate service.

At half-past 12 P. M., tacked and stood for the batteries. Backed the main-topsail. At half-past one P. M., made the general signal to follow the motions of the Commodore. Filled the main-topsail and stood in towards the batteries. At quarter past two, made the signal for the bombs and gunboats to advance and attack the ships and batteries. At half-past two, general signal for battle. The whole squadron advanced within point-blank shot of the enemy's batteries and shipping, our gunboats in two divisions; the first consisting of three boats commanded by Captain Somers, the second of three boats, by Captain Decatur. At ¾ past two the action commenced on our side by throwing a shell into the town, and in an instant the whole squadron was engaged. The enemy's gunboats were anchored with springs on, in three divisions. The eastern or van division consisted of nine boats, the centre of seven boats, and the western or rear of five boats. As the wind was from the eastward, our boats were ordered to lead in to windward, and attack the enemy. The rear and centre divisions of the enemy's boats are close under their batteries, and the van division, consisting of their largest boats, is within grape distance of the Pasha's castle and Fort English. At 3, observed our gunboats in close action with the enemy's boats, while a tremendous fire was kept up by this

ship and the rest of the squadron. Capt. Decatur, with No. 4, Lieut. Trippe of No. 6, and Lieut. Bainbridge, of No. 5, and Lieut. James Decatur, of No. 2, attacked the enemy's boats within pistol shot. No. 1, Capt. Somers, fell to leeward, but fetched up with the enemy's rear of five boats, which he gallantly attacked, disabled, and drove in, although within pistol-shot of the batteries. No. 3, Lieut. Blake, did not go into close action. Had he gone down to the assistance of Capt. Somers, it is probable they would have captured the rear boats. Capt. Decatur boarded, and after a stout and obstinate resistance, took possession of two of the enemy's gunboats. Lieut. Trippe boarded and carried a third. Lieut. James Decatur, in the act of boarding to take possession of the fourth boat, was shot through the head and mortally wounded. The officer next in command, Mr. Brown, hauled off. Lieut. Bainbridge had his lateen-yard shot away early in the action, which prevented him from taking a boat, but he galled the enemy by a steady fire within musket-shot. Indeed he pursued the enemy until his boat touched the ground under the batteries. The bombs kept their stations, which were well chosen by Lieut. Dent and Lieut. Robinson, who commanded them, and threw a number of shells into the town, although the spray of the sea occasioned by the enemy's shot almost covered them. Three different times the enemy's gunboats rallied, and attempted to surround ours. I as often made the signal to cover them, which was properly attended to by the brigs and schooners; and the fire from this ship not only had the desired effect on the enemy's flotilla, by keeping them in check and disabling them, but silenced one of their principal batteries for some time. At ½ past 4 P. M., made the signal for the bombs to retire from action out of gunshot; and a few minutes after the general signal to cease firing, and tow out the prizes and disabled boats. Sent our barge and jolly-boat to assist in that duty. Tacked ship, and fired two broadsides in stays, which drove the Tripolines out of the castle and brought down the steeple of a mosque. By this time the wind began to freshen from N.E. At 4 ¾ P. M., hauled off to take the bombs in tow. At 5 P. M., brought to, two miles from their batteries. Received Lieut. James Decatur on board from gunboat No. 2. He was shot through the head, in boarding a Tripoline boat which had struck to him. He expired in a few moments after he was brought into the ship. We lay to until 10 P. M., to receive the prisoners on board captured in the prizes; then made sail and stood off to the N.E., the wind varying to the E.S.E. We have all the surgeons of the squadron on board, dressing the wounded.

During the action we fired two-hundred and sixty-two round shot, beside grape, double-head, and canister, from this ship, and were several times within three cables' lengths of the rocks and batteries, where our soundings were from ten to sixteen fathoms. The officers, seamen, and marines of the squadron behaved gallantly throughout the action. Capt. Decatur, in gunboat No. 4, particularly distinguished himself; as did Lieut. Trippe of No. 6. Our loss in killed and wounded has been considerable.

The damage we received in this ship is a twenty-four pound shot nearly through the centre of the mainmast, thirty feet from the deck, main-topgallant R. yard* and sail shot away, one of the fore shrouds cut away, the sails and running rigging considerably cut. One of the twenty-four pounders on the quarter-deck was struck by a twenty-four pound shot, which damaged the gun and carriage, and shattered the arm of a marine to pieces. Gunboat No. 2 had her lateen-yard shot away, and the rigging and sails of the brigs and schooners were considerably cut. We captured three gunboats, two of which carried each a long brass twenty-four pounder and two brass howitzers, and thirty-six men, with plenty of muskets, pistols, pikes, sabres, &c. The other mounted a long brass eighteen pounder and two howitzers, and [had] twenty-four men. Forty-four Tripolines were killed on board of the three boats, and fifty-two made prisoners, twenty-six of which were wounded, seventeen of them very badly; three of which died soon after they were brought on board. The enemy must have suffered very much in killed and wounded among their shipping, and on shore. One of their boats was sunk in the harbor,† several of them had their decks nearly cleared of men by our shot, and several shells burst in the town, which must have done great execution.

We have lost in killed and wounded, viz.:

| Killed. | Wounded. |
|---|---|
| Lt. James Decatur. | Capt. Decatur, slight. |
| | Lieut. Trippe, severely. |
| | 10 seamen and marines wounded. |

Total. 1 officer killed.
2 officers wounded.
10 seamen and marines wounded.
——
13

* Main-topgallant and royal yards?

† Preble's official report mentions three of the enemy's boats that were sunk.

SUNDAY, 5th August, 1804.

Fresh breezes, E. by N.; at anchor, seven or eight miles from the city of Tripoli, bearing south. Squadron and prizes in company. Every one busily employed in preparing for another attack on Tripoli. The Argus in chase of a small vessel to the westward. At 1 P. M., the Argus brought the chase within hail and anchored. She is a French privateer of four guns; sailed from Tripoli this morning, and brought me letters from the French Consul. The Captain informed me that he put into Tripoli for water, being in distress for that article. I prevailed on him for a consideration to convey fourteen badly wounded Tripoline prisoners to Tripoli, which I put on board him with a letter to the French Consul, and one to the Prime Minister. At half past one P. M., made signal for all Captains. At two P. M., the body of Lieut. James Decatur was committed to the deep with the usual military honors. His funeral was attended by the officers of the squadron. At 6 A. M., the French privateer weighed and stood in to the harbor. Ordered our three spare top-gallant masts, for masts for the prize gun-boats; all hands employed in rigging and fitting them for service. They each carry a brass cannon of twenty-seven pound ball, and two brass howitzers. Caused general orders of thanks to be read on board each vessel of the squadron.

MONDAY, 6th August, 1804.

At anchor, two leagues north of Tripoli with the squadron. Employed the ship's company in fitting the prize boats and supplying the squadron with provisions, water, and military stores. All the sailmakers in the squadron are employed in making sails for the prizes. The Vixen was kept under way all night, making false signals to alarm the enemy. At noon, wind N.N.W.

TUESDAY, 7th August, 1804.

Wind N. by W., cloudy; at anchor off Tripoli. Making arrangements for a second attack. At half past one, made signal to prepare to weigh, but falling calm, annulled the signal. In the evening the French privateer came out. At eleven, the French captain came on board with a letter from the Consul of his nation, in which he says our attack of the third has disposed the Pasha to accept of reasonable terms, and invites me to send a boat to the harbor as a flag; but as no specific sum is mentioned, and no security for the boat can be depended on, I declined the invitation. At nine A.M., the squadron weighed per signal, and stood in shore towards the

western batteries. The gunboats, nine in number, with the addition of the prizes, now completely fitted and manned, and commanded by Lieut. Crane of the Vixen, Thorn of the Enterprise, and Caldwell of the Siren. The whole advanced with sails and oars, with orders to attack the western batteries, and throw shells into the city. At this time we were at anchor six miles from the city, calm, and a current so strong to the eastward, that [we] remain at anchor. Our topsails and top-gallantsails are set ready for the first breeze; the Argus, Siren, Vixen, Nautilus, and Enterprise, becalmed, three miles within us; gunboats and bombs advancing to the attack.

Wednesday, 8th August, 1804.

At anchor, six miles N.N.E. from Tripoli, becalmed. The gunboats and bombs advancing with all their sweeps. At ½ past 1, a light breeze from the N.N.E. We immediately weighed and stood in for the town, but, the wind being on shore, could not, with prudence, attack or allow any of the squadron to attack the batteries, as, in case of a mast being shot away, the loss of the vessel would probably ensue. At ½ past 2 P. M., made the signal for the gunboats and bombs to attack the batteries and town from the west, when they immediately opened a tremendous fire, within half-cannon-shot of the town, and less than that distance of the battery of seven heavy 24-pounders. This battery in less than two hours was silenced, excepting one gun. I presume the others were dismounted, as the walls were almost totally destroyed. The bombs were well and effectually employed by Lt.-Com'd't Dent and Lt. Robinson, of the Constitution. Lieut. Robinson, from a dangerous position he took, threw 28 shells into the town, but the well-directed fire of heavy artillery from the enemy obliged him to shift his station, not, however, until the clothes of every man in the boat were wet through with the spray of sea which the enemy's shot threw over them. Lieut. Dent threw 20 shells from a position not so favorable as Lieut. Robinson's, but which a strong westerly current in shore would not allow him to change. At ¼ past 3 P. M., a frigate in sight in the offing, standing for the town. Made the Argus's signal to speak; ordered her to chase the strange sail. At ½ past 3 P. M., the magazine of one of our gun-boats, No. 9, blew up, and she immediately sank. She had on board thirty officers, seamen, and marines, ten of which were killed and six badly wounded. Among the killed were Lieut. J. R Caldwell, first of the Siren, and Mr. Dorsey, midshipman, two good officers. Mr. Spence, midshipman, and thirteen men were picked up

unhurt. The enemy's gun-boats and galleys, seven in number, are all in motion under their batteries, and appear to meditate an attack on our bombs and gun-boats.

Ordered the Argus, Nautilus, and Enterprise to windward in reserve to cut them off from the harbor, if they should attack; and the Siren and Vixen to leeward to support and cover any of our boats that might be disabled. Kept to windward with the Constitution, ready to bear down and support the whole. At ½ past 5 P. M., the wind began to blow fresh from the N.N.E. Made the signal for bombs and gunboats to retire out of gunshot of the enemy, and be taken in tow by their respective vessels. At 6 P. M., the Argus made signal that the strange sail was a friend. In the action of this day, No. 6, Lieut. Wadsworth, had her lateen-yard shot away; No. 4, Capt. Decatur, a shot in the hull: No. 8 lost two men killed by a cannon-shot. Some of the other boats received trifling damage. The gunboats fired about 50 rounds each. The enemy must have lost many men, and the buildings in the city must have received considerable damage from our shot and shells. All the officers and men engaged in action behaved gallantly. At ¾ past 6, all the boats were in tow, and the squadron standing off to the northwest. At 8, the John Adams, store-ship, Capt. Chauncey, joined company. At 9, being N.W., about five miles from Tripoli, made signal to anchor, and came to with the squadron in thirty-five fathoms water, hard bottom. Capt. Chauncey came on board, and brought me dispatches from the Navy Office, announcing that four frigates, the President, Commodore Barron, who is to supersede me in the command of the Mediterranean Squadron, the Congress, Capt. Rodgers, Constellation, Capt. Campbell, and Essex, Capt. Barron, were ready, and would sail in a day or two after the John Adams. Captain Chauncey brought me a letter from the Navy Office, approving my conduct, and stating that the supersedure had been necessary to enable them to send the frigates out, as only two junior Captains to myself were in the United States. He also brought me the thanks of the President for my services, which have been conveyed to me by a letter from the Secretary of the Navy. How much my feelings are lacerated by this supersedure at the moment of victory cannot be described, and can be felt only by an officer placed in my mortifying situation.

Gave Capt. Chauncey orders to remain with the squadron for the present.

THURSDAY, 9th August, 1804.

Wind N.W. At anchor with the squadron, N. W. from Tripoli,

five or six miles. Supplying the gunboats and bomb-vessels with ammunition and stores. At 3 P. M., went on board the Argus to reconnoitre the harbor of Tripoli. Stood in for the eastern batteries. The enemy fired several shots, one of which was near sinking us, as it struck below the water-line, and raked the copper down the bottom. At 3½ P. M., made the signal for the squadron to weigh and haul off, the wind blowing fresh from the N.N.E. At 6 P. M., joined the Constitution. A small ketch stole into the harbor under the eastern shore, while we were reconnoitering. The shoals prevented our cutting her off. Fresh breezes all night; in the morning, calm. At 9 A. M., anchored with the squadron, 36 fathoms, five miles N.N.E. from the town. At 10 A. M., the French Consul hoisted a French flag and a white flag under it, at his flag-staff on shore; in consequence of which I hoisted similar colors on board the Argus, and stood in near the town, and sent a boat into the harbor with a flag of truce, and a letter for the Prime Minister, one for Captain Bainbridge, enclosing an invoice of clothing provided by Mr. Cathcart, and a letter to the French Consul. The Scourge joined company. Lieut. Izard reported that he convoyed the store-ship safe into Malta.

Friday, 10th August, 1804.

Wind N.N.E. to E.N.E. At anchor, two leagues N.N.E. from Tripoli. All the squadron at anchor, except the Argus and Vixen as guardships. At half past 12, noon, observed the French flag with a white flag under it, hoisted at the staff on top of the French Consul's house in Tripoli. I ordered the Argus and Vixen to answer the signal by hoisting similar flags. I then sent a boat into the harbor with a flag of truce. Mr. O'Brien went in as officer of the boat. At 3 P. M., the boat returned, and brought me a letter from the French Consul, advising me to offer the Pasha one hundred and fifty thousand dollars for ransom of the prisoners, and make peace. This I did not think proper to do, presuming that our government might not be satisfied with the terms, although it is my opinion that we shall not be able to obtain them for a less sum.

Moderate all night. All the squadron employed in preparing for a third attack. At 11½ A. M., the French Consul hoisted the French and white flag. Sent a boat into the harbor with a flag of truce and a letter, authorizing the French Consul to offer the Pasha one hundred thousand dollars for ransom of the prisoners, ten thousand as a consular present, nothing for peace, and no tribute. These terms were rejected.

Saturday, August 11, 1804.

Wind E. by N., light breezes. Held communication with the French Consul in Tripoli, by means of a flag of truce, but without any effect. The Pasha's demands are too extravagant to be complied with. Received on board sundry stores from the John Adams.

Sunday, 12th August, 1804.

Moderate breezes, E. by N. Lying to, three or four miles to the N.N.E. of Tripoli, the John Adams at anchor, two leagues out, to prevent the Tripolines from discovering that she has but a few guns. Every thing is in order throughout the squadron for an attack on Tripoli this night. The enemy has two galleys, a schooner of 10 guns, and sixteen gunboats moored in the harbor, in a line abreast from east to west, heads to the northward, to defend it. A swell heaving on shore prevents our attempting any thing at present. Anchored in 26 fathoms water, Tripoli bearing south three miles. From daylight to 7 A. M., calm. At 8, a breeze from the N. by E. The swell increasing, ordered all the squadron under way, to stand off from the land.

Monday, 13th August, 1804.

Wind N.E.; a heavy swell setting on shore. Hauled off to the N.N.W. with the squadron. At 6 P. M., signalled to close, to prevent separation. At 10, the wind veered to the E.S.E. Hauled up to the N.E., and stood off all night under easy sail. At 4 A. M., wore ship, and stood for the land. At daylight, Tripoli in sight, bearing S. by W., five leagues distant. We are now waiting for a favorable night to attack Tripoli. The wind must be to the southward of east, and sea perfectly smooth, to enable us to attack with any prospect of success. At noon, Tripoli bears S. by W., five miles; wind E.N.E. and a favorable swell setting on shore.

Tuesday, 14th August, 1804.

Wind E. by S.; standing off and on, four or five miles from Tripoli. At 6 P.M., all the squadron were in close order, ready to push in after dark. The John Adams manœuvred several deceptions, per signal, for weighing and standing in with the squadron, but, as soon as dark, she was ordered to hand sails, and remain at anchor. Capt. Chauncey, with several of his officers, 250 seamen and marines, came on board as volunteers for the attack. At 9 P. M., the wind freshened from E. by N., and increased the sea so much as to make an attempt imprudent. I accordingly stood off shore, and anchored in thirty-seven fathoms water. Captain Chauncey, with his officers and men, returned to the

John Adams. Two of our gunboats carried away their lateen-yards; supplied them with new ones. We had strong breezes all night and until noon. Lat. observed 33° 2′ N.

WEDNESDAY, 15th August, 1804.

Strong breezes from the E.S.E. At anchor, six miles to the north of Tripoli. Ordered the Vixen to cast off her gunboats, and look out to the eastward, and the John Adams to take her boats in tow. At 4 P. M., down royal and top-gallant yards. Fresh breezes through the night. At 10 A. M., wind E. by N., and a rough sea. Latitude observed 33° 2′ N.

THURSDAY, 16th August, 1804.

Fresh breezes from the E. by N. At anchor, N. by E. ½ E. from Tripoli; all the squadron at anchor, except the Vixen, on the lookout to the eastward. At 8½ P. M., the Enterprise sailed for Malta, under command of Lieut. Lawrence, with letters for Mr. Higgins, directing him to send transports with water and vegetables. The scurvy has made its appearance among the men on board some of the vessels of the squadron, and our fresh water is getting short. Surgeons report six sick, and four convalescent.

FRIDAY, 17th August, 1804.

Moderate breezes from the E.N.E., and pleasant weather. At anchor, five miles to the N. by W. of Tripoli. At 3 P. M., got all boats, and armed them for an attack. At 5 P. M., all the squadron, excepting the John Adams and Scourge, were under way, standing for Tripoli. By this time, the wind had veered to N.E. by E., and the current setting strong to the westward. In the evening, Capt. Chauncey, with several officers, and 250 seamen, from the John Adams, came on board, volunteers for the intended attack. At 7 P. M., we were four miles from the town, tacking and manœuvering the squadron, waiting for the wind to come from the E.S.E. From 8 to 9 P. M., we stood in for the batteries, with a light breeze from E. by N. At 9¾, almost calm, the town bearing S. by W., the batteries fired eleven shot at us, which fell short. The current setting to the S.W., pressing us down on the western batteries, and the wind very light, I thought prudent to haul off. At 11 P. M., wore ship, and stood in again for the town, in hopes the wind might increase. The enemy fired fourteen shot at us from their batteries, which fell short. It being by this time past midnight, and almost calm, hauled off, and at 1, made the signal to anchor, and came to in twenty-five fathoms, Tripoli S. by W., three miles distant.

SATURDAY, 18th August, 1804.

Wind N.E. We are at anchor, three miles N. by E. from the town of Tripoli. We have our guns all clear, boats all out and armed, and everything prepared for an attack, the moment the wind and sea are favorable. At 8 P. M., I sent Capt. Decatur and Capt. Chauncey, in two small boats, to reconnoitre the harbor, and examine the situation of their gunboats. At midnight, they returned and reported that they rowed to the western rock, within musket-shot of the enemy's sentinels, and that all the gunboats were in the mole, moored in a line abreast, with heads to the eastward. By 1 A. M., the wind had shifted to the S.E., which blows out of the harbor, the sea was smooth, but the current strong to the westward, which concludes us to defer an attack until some better opportunity, as the boats would not be able to reach their stations before daylight. At daylight, the wind suddenly shifted to the N.N.W., which immediately brought a heavy swell on shore, the sky was clouded, and appearances of a gale. Made the signal for the fleet to weigh, and gain an offing. At 7 A. M., weighed, and made sail to work off shore. At 11½ A. M., double-reefed the topsails; fresh breezes, and rough sea, Tripoli S. by E., three leagues distant.

SUNDAY, 19th August, 1804.

Wind N.W. At 1 P. M., wore to the N.E., and brought to for the squadron. Capt. Chauncey, with his officers and crew, rejoined the John Adams. Hoisted in all our boats, and made signal for all boats to join their respective ships. At 5 P. M., the wind north; stood to the E.N.E., with the fleet. At midnight, wore to the W.N.W. Signal was made for the squadron to do the same. Fresh breezes and rough sea. At 6 A. M., sounded 75 fathoms of water, sandy bottom. We have now an offing of eight or ten leagues from Tripoli.

Moderate breezes all the forenoon, with an ugly swell setting towards the coast. Tripoli at noon bore S. by W. ½ W., nine leagues distant. The clouds are dispersing, and the weather appears favorable for a change of wind. Latitude observed, 33° 19′ N.

MONDAY, 20th August, 1804.

Moderate breezes from the N.E., with a heavy swell setting to the N.N.W. Standing to the N.N.W., with the fleet, Tripoli bearing S.S. E., nine or ten leagues. At 1 P. M., a strange sail was discovered from the John Adams in the E.N.E. Made the Argus's signal to cast off her gunboats and chase. Made the John Adams's signal to tow the

Argus's boats. At 4 P. M., the Argus brought the chase to. Made the signal to bring her down to me. At 6, the Argus and chase joined company. She proved to be the U. S. Ketch Intrepid, from Syracuse, with water and fresh stock for the squadron. She brought me letters from Mr. Dyson and Mr. Higgins. The latter informs me that an English vessel left Malta the 12th inst., with a hundred and ninety butts of water, and some live stock, for the squadron. We are in great want of the water, but I fear some accident has happened to her, to prevent her arrival, as the wind has been constantly fair for several days past. At 12, midnight, the wind E. by S., steered to the S. by E. At 2½ A.M., the wind S.S.E., wore ship to the E. At 5½ A.M., wind S.E., wore to the S.S.W. At 8 A.M., all sail set for the land. At 9 A.M., ordered the Argus to the eastward, to look out for the storeship expected from Malta. Sent the Vixen to the westward on the same errand. Ordered all the fleet on allowance of water, two quarts per day, cooking and grog water included; the prisoners at 1 quart per day, which is more than an equal proportion, as they are not exposed to the sun, and have no work to do. At noon, we were about five leagues from the coast, Tripoli bearing S.E. by S., latitude 33°4′ N.

Tuesday, 21st August, 1804.

Moderate breezes from the E.S.E., and pleasant weather. Standing in for the coast of Tripoli. All the squadron in company excepting the Argus, on the lookout to the eastward. At 1 P. M., the town of Tripoli in sight, bearing by compass S.E. by S., four leagues. An unexpected westerly current has carried the squadron four or five leagues further to leeward than we expected. Carrying a press of sail all night to gain our station off the town. Wind variable in the night. By 7 A. M., the wind had shifted from E.S.E. to S., Tripoli bearing S. W. by S. five leagues. At 9 A. M., saw a strange sail in the S.E. quarter. Gave chase; made signal for the Argus and Vixen to chase, the other vessels of the squadron repeating. At 11½ A. M., they bore up to comply with the signal.

Wednesday, 22nd August, 1804.

Wind W.N.W., light breezes. In chase to the S.E. Made signal for the John Adams to act discretionary. At 3 P. M., brought to the chase, a Maltese ship, from Malta, with a supply of water, live-stock, and vegetables. At 5 P. M., wind shifted to the S.E. The Argus was ordered to tow the store-ship. At 7 P. M. we were four leagues from

Tripoli, standing for the John Adams ; Siren, Scourge, and Nautilus at anchor.

[At this point, Commodore Preble's MS. comes abruptly to an end. For the remainder of the operations before Tripoli, the reader is referred to Preble's official report to the Secretary of the Navy, published in the American State Papers, Naval Affairs, 1. 133, and in Goldsborough's Naval Chronicle.]

# THE RECORD

OF THE

# UNITED STATES NAVAL INSTITUTE.

U. S. NAVAL ACADEMY, ANNAPOLIS,

FEBRUARY 13, 1879.

Professor C. E. MUNROE in the Chair.

## ON RECENT MODIFICATIONS OF THE EXPLOSIVE FORCE OF GUNPOWDER.

BY LIEUTENANT COMMANDER W. M. FOLGER, U. S. N.

*Mr. Chairman, and Gentlemen:*

Before touching upon the changes which have been effected in our own day in the burning qualities of gun-powder, I have thought it might not be uninteresting to present a short outline of the experiments of the early investigators. This may also aid us in appreciating the line of thought adopted in later years, as progress in science has furnished additional tools to work with.

The problem forced itself into prominence with the earliest improvements in artillery, but there are no records of definite experiment before those of La Hire, in 1702. La Hire's conclusions were quite defective, but possess a certain interest regarded in the light which has been thrown upon the subject since his time. He ascribes no rôle whatever to the products of combustion, but supposed the energy was due entirely to the expansion of the air contained in and among the grains of powder, the latter merely furnishing the heat for expansion.

In 1742 Robins took up the subject, and, as the result of experiment, deduced that the volume of the products of combustion was two hundred and forty times greater than that of the original solid, and that the maximum pressure of powder fired in a confined space was one thousand atmospheres.

Robins further shewed the fallacy of La Hire's conclusions, proving that the expansion of the air in the powder space could not effect a pressure exceeding five atmospheres.

In 1778 Dr. Hutton, of Newcastle on Tyne, gave as the result of experiment the maximum pressure as double that of Robins, or two thousand atmospheres.

In 1797 we find Count Rumford attacking the problem in his characteristic, practical way, and his valuable contributions to science in other fields entitle his conclusions to great weight. As Captain Noble and Professor Abel remark in the admirable sketch of their own experiments, from which, I may state here, the historical and statistical portions of these notes are mainly drawn, Rumford's trials remain to this day the standard, if not the only series of experiments, in which the pressure has been determined by direct observation.* His results have, however, been questioned on theoretical grounds by a number of writers on the subject.

Rumford conducted his experiments on very much the plan which has been used in later years in the proof of gunpowder. The firing was effected in a small, strong eprouvette-shaped vessel of about 0.08 cubic inch internal capacity. The muzzle was closed by a metallic hemisphere upon which weights were placed until the elastic force of the expanding gases was exactly counterbalanced. A simple calculation then gave him the pressure per unit of area. After an exhaustive series of trials, in describing which he makes numerous deductions which have been completely verified by later experiments, he gave as the pressure of exploding gunpowder confined in its own volume one hundred and one thousand and twenty-one atmospheres.

Considering the great discrepancy between this result and that obtained by other investigators, it is interesting to note the characteristics of the powder used in Rumford's experiments, and we find it to have been fine grained sporting, containing but sixty-seven per cent. of nitre, of a specific gravity of 1.868, and gravimetric density, 1.08.

In 1823, Gay-Lussac found, by an entirely different process, (by dropping grains of powder into a red hot tube provided with an arrangement to receive the gases), the volume of the products to be four hundred and eighty times that of the original solid. Piobert criticised this result and appears to have proven that, considering Lussac's own statement, the results were by error nearly doubled, and that the true increase of volume was two hundred and fifty, which agrees very nearly with other writers.

The results of the experiments of General Piobert in 1830-31, form an important page in powder literature. This investigator first devel-

* Researches on Explosives, Noble and Abel, 1875.

oped the idea that the point of ignition had great influence on pressure and velocity. He also details the effect of the presence of moisture, regarding which there has been considerable controversy.

The modern science of chemistry was at this time in its infancy, but was applied with considerable success in the estimation of products of combustion. Piobert makes one capital error in his deduction that the high temperatures and great tension of the gases have no sensible effect in increasing the rapidity of combustion of the individual grains.

The results of his experiments give the increase of volume to be about three hundred and the maximum pressure as twenty-three thousand atmospheres, which agrees quite well with Rumford's first series of trials, of which I have quoted but the second.

In 1842, General Cavalli proposed and experimented with a piece of artillery, in which, at various distances along the length, tubes of wrought iron were inserted, in each of which was placed a spherical bullet, to be projected by the charge of the piece, in driving out its own projectile. The tension at the several points was estimated from the velocities imparted to the bullets.

Cavalli also deduced the theoretical strength of metal needed at various distances from data procured in this manner. The maximum pressure in the bore of a gun, obtained by Cavalli, was placed at the extremely high figures of from four thousand to twenty-four thousand atmospheres, varying with the different qualities of powder.

In 1854, a Prussian Commission experimented with an arrangement somewhat resembling Cavalli's, in which a small cylinder was projected instead of a spherical bullet. Their conclusions differed materially, however, the pressure for the 6 pounder field-piece being estimated at only eleven hundred atmospheres, and for the 12 pounder, thirteen hundred atmospheres.

We have now reached the period of Major Rodman's experiments, 1857–8, the importance and value of which are recognized in the practical utilization to-day of most of the ideas he developed. It is well to remember his work, when we read in a recent English scientific journal, that to Germany belongs the credit of the invention of prismatic powder.

You are all acquainted with the Rodman method of measuring pressures, which has been used by the Navy Bureau of Ordnance for the past fifteen years. The Woodbridge modification, recently adopted, does not differ in principle from the original idea. In place of the cutter, a hollow punch, provided with a spiral cut in relief on its sur-

face, is pressed over a copper disc, and the length of the impression measured and compared with a similar indentation made by mechanical appliances.

Rodman's experiments to determine the maximum pressure of confined powder were conducted in a manner which does not admit of direct comparison with the results obtained by other investigators. In noting his figures—from four to thirteen thousand atmospheres—it is necessary to remark that he exploded his charges through a vent in a cast-iron shell (provided with his pressure gauge), thus using an arrangement in which the conditions of explosion in a confined space and those which obtain in the bore of a gun are combined.

In 1856, Messrs. Bunsen and Schischkoff made an exhaustive series of trials to determine the products of combustion of gunpowder, to which Professor Munroe, of the Department of Physics and Chemistry, made reference, from a chemical stand-point, in his interesting paper on the "Causes which promote Explosion," read before the Institute, in 1877.

These experiments were conducted in a manner somewhat resembling Gay-Lussac's,—the powder grains being allowed to pass singly into a heated bulb, the gases being collected in a series of tubes.

The results obtained were that the gases form thirty-one per cent. of the weight of the original solid, with a volume two hundred times as great. Their maximum pressure was calculated to be forty-three hundred and seventy atmospheres, and the temperature of explosion in a confined space 3300° C. These writers also estimated the theoretical work of a kilogramme of gunpowder to be sixty-seven thousand kilogrammêtres.

We will consider Noble's and Abel's experiments with more minuteness, their work being the most exhaustive research that has been made, as well as the most recent.

The powder charge, a kilogramme in weight, was exploded in a strong cylindrical-shaped vessel of mild steel, carefully tempered in oil. (Fig 1). The *firing plug* C is provided with a second interior plug D conical in shape with tissue paper as an insulator between contact surfaces. At E is the arrangement for allowing the gaseous products to escape, either through the outlet H for analysis, or the plug aperture E for measurement of volume. The two wires L L are connected with a short platinum wire passing through a small glass tube filled with mealed powder, thus constituting an arrangement for firing by electricity.

These writers say: "the difficulties met with in using this apparatus are more serious than might at first sight appear. In the first place, the dangerous nature of the experiments rendered the greatest caution necessary, while, as regards the retention of the gaseous products, the application of contrivances of well known efficacy for closing the joints, such as papier maché wads between disks of metal, (a method which has been successfully employed with guns) are inadmissible, because the destruction of the closing or cementing material used, by the heat, would obviously affect the composition of the gases. Every operation connected with the preparation of the apparatus for an experiment has to be conducted with the most scrupulous care. Should any of the screws not be perfectly home, the gases, instantly on their generation, either cut a way out for themselves, escaping with the violence of an explosion, or blow out the part improperly secured—in either case destroying the apparatus."

Messrs Noble and Abel further note the difficulty experienced in withdrawing the firing and pressure plugs and to the cementing effect of the powder residue when subjected to the high pressures of explosion, and the interesting fact that the solid residue is in a liquid state immediately following the instant of explosion. This was surmised from the appearance presented on opening the vessel, and afterwards demonstrated by tilting the cylinder 45° and then righting it after a period of two minutes. On opening, the marks of the displaced residue were plainly visible. The pressures were calculated from the chemical data and also measured with the crusher gauge.

The volume of the permanent gases was measured by the apparatus shown in Fig's 2 and 2a which need no description.

To collect the gases for analysis, the outlet H was used, the plug E being only started from its seat. The operation of transferring them from the cylinder to the tubes over mercury occupies from five to fifteen minutes, and the experimenters believe no change in their nature takes place, through contact with the solid residue, in this interval.

Great difficulty was experienced in collecting the solid residue, it being so solidly packed on the bottom and sides of the vessel as to require to be cut out with steel chisels. The tendency of the residue to absorb oxygen from the air is referred to, and a case is cited in which the heat developed was sufficient to burn the paper on which it was placed. The writer has frequently observed this phenomenon in the residue from the one hundred pound charge of the XV$^{in}$ gun, and

noticed also, that other portions from the same discharge would absorb moisture so rapidly as to entirely change their physical qualities.

In the summary of results, the following points are of interest, and can be mentioned in a paper of this character.

Taking as a unit the volume of a cubic centimetre:

1. On explosion, the products of combustion consist, by weight, of fifty-seven per cent. of matter which ultimately becomes solid and forty-three per cent. of permanent gases.

2. At the instant of explosion the liquid products occupy 0.6 cubic centimetre and the gaseous products 0.4 cubic centimetre. At 0° C and $760^{mm}$ pressure, they will occupy 280 centimetres, or 280 times the volume of the original solid.

3. The maximum pressure when powder is fired in its own space is about sixty-four hundred atmospheres.

4. The temperature of explosion is about 2200° C.

The writers further discuss the action of the gases when powder is burned in the bore of a gun, taking data furnished by experiments made by the *Committee on Explosives*, and deduce as follows:

1. The products of combustion, in so far as the proportions of solid and gaseous products are concerned, are the same as in the case of powder fired in a confined space.

2. The work done on the projectile is due to the elastic force of the permanent gases.

3. The reduction of temperature due to the expansion is compensated for by the heat stored up in the liquid residue.

4. The total theoretic work done, when powder is indefinitely expanded, is about 480 foot-tons per ℔ of powder.

In enumerating the foregoing results of the various investigators, I have purposely abstained from any mention of the chemical reactions which take place in the formation of the products of combustion whether solid or gaseous. You would find on comparison from Piobert's experiments to those of Noble and Abel a most confusing lack of uniformity. No two series of experiments have produced identical results, and among the gaseous products you would occasionally find combinations in one series which are entirely absent in the others. On this subject Noble and Abel frankly admit, as a result of their work, that the variations of composition in the products, both solid and gaseous, under similar conditions of powder composition, pressure, size of grain, density etc, are so considerable, that no value can be attached to any attempt to give a chemical expression for the reactions.

The gaseous products found are:

Carbonic Anhydride,
Carbonic Oxide,
Nitrogen,
Hydrogen Sulphide,
Marsh gas,
Hydrogen, and
Oxygen.

The solid products:

Potassium Carbonate,
Potassium Sulphate,
Potassium Hyposulphite,
Potassium Monosulphide,
Potassium Sulpho-cyanate,
Potassium Nitrate,
Potassium Oxide,
Ammonium Carbonate,
Sulphur, and
Charcoal.

The straits in which the French people found themselves, during the latter part of the Franco-Prussian war, in regard to material, called forth considerable effort from their scientific men, and produced, with others, a remarkable treatise from Professor Berthelot of the College de France on the force of the expanding gases of gunpowder. *

Berthelot claims that the results of Bunsen and Schischkoff regarding the pressure and temperature of explosion are much underestimated, as at this high temperature the gaseous products are in a more elementary conditon, or are "dissociated." Their separation, he admits, determines a loss of heat, but this is compensated for at their recombination which is rendered possible by the fall in temperature due to the displacement of the projectile.

Berthelot further discusses the effect, on the pressure exerted, of the change of coefficient of expansion, as under the conditions of explosion the laws of Mariotte and Gay Lussac do not hold; and deduces therefrom an increase of pressure as compared with that calculated by these laws.

Messrs Noble and Abel take exception to this assumption of the dissociation of the gaseous products, and also to the pressure deduced by Berthelot, (sixty thousand atmospheres), but it does not appear that all

* Force de la Poudre et des Matieres Explosives Paris 1872.

of Berthelot's arguments are satisfactorily refuted. In his lectures before the British Association at Edinburgh in 1871 Professor Abel gives Berthelot's results with the supplementary remark that they have not been verified by experiment.

But passing these disputed points, which in reality have but little interest for us, let us consider the more positive results obtained by these experiments.

We find on comparing their tables:

1. Variations in the proportional parts of the mixtures produce uniform effects on velocity and pressure, and in this connection it is interesting to note that, with comparatively slight changes the relative weights of nitre, sulphur and charcoal remain the same from La Hire's time to the present day.

2. The size of the grain, as affecting burning surface.

3. Variations in specific gravity and gravimetric density having a uniform effect on pressure and velocity.

4. The effect of moisture in incorporation, an excess decreasing both pressure and velocity: in this connection we note also the effect of moisture absorbed after manufacture, and the influence of density, size of grain, glaze, and quality of coal, (either as regards the wood from which prepared or amount of carbonization), on the absorptive capacity of the grain.

5. The shape of the grain and the effect of uniformity in this respect in limiting burning surface.

6. The point of ignition, the pressure being much greater when ignited at the rear.

7. The effect of glazing, the lead used in this process collecting on each grain a thin layer of dust, which increases the rapidity of ignition.

8. The size of the charge, an increase in weight augmenting the rapidity of combustion.

With a knowledge of the effects of variation in these points, the powder men are not entirely unprepared as new devices in gas-check-rings, and expanding bands, or changes in grooving, are proposed, and we will now consider the more notable modifications which have been suggested.

Rifled guns demanded a less violent explosive, and we can observe the change in the powder curve by comparing the profile of the Dahlgren system (which is not by any means a bad representation of the old powder curve) with the lines of the latest system of rifled ar-

tillery. The present curve has a much shorter initial ordinate, and does not fall nearly so abruptly. In the gun we see a relatively smaller diameter at the breech with the strengthening bands extending toward the muzzle. A neglect of the principles of equilibrium between the two and we have the oft repeated accident of the muzzle's blowing off.

The powder experts first increased the size of the grain to diminish burning surface, and we see Rodman's mammoth or pebble grain used all over the world.

The English produce their pellet in regular forms and the Germans adopt Rodman's prismatic grain with its seven perforations, and are imitated by the Russians, Austrians, Spaniards, Italians, Turks and Eygptians.

A few words regarding Prismatic Powder may not be uninteresting.

A Russian officer, present at the original experiments of Major Rodman, at Fortress Monroe, in 1861, was struck with the idea and carried it to Europe. The ingenious mechanical contrivance, at present used in pressing the prisms, is the invention of the Russian Professor Vichnegradski.

The general principle of the increasing burning surface in the prismatic grain, is theoretically very advantageous, ensuring a uniform augmentation in the pressure exerted; but actual practice in service has demonstrated the fact that this cannot always be depended upon. A slight deviation in the continuity of the perforations through the entire charge, or a want of precaution in assuring solidity in the system, and the first rush of gas breaks the grains into fragments which are then consumed with much greater rapidity and consequent unsafe pressures. To this cause may be mainly ascribed the large number of Krupp guns which burst during the Franco-German war, the list of which appeared in the Engineering newspaper a few years since.

The prismatic grain ignites slowly and with safety, being very dense, and having a smooth polished surface which is generally covered with a slight efflorescence of saltpetre. To eliminate the defect of 'breaking up,' the Germans reduced the number of perforations to a single one in the center, but recent reports speak of the merely comparative success of the innovation, and a return to solid grains has been proposed. In view of this fact, it is interesting to note the recent adoption, by the English, of prismatic powder for the 80-ton gun.

The progressive powder of Colonel, now General, de Reffye, burns on the same principle as the prismatic grain, being simply a cartridge

built up of a number of disks or cakes having a large central perforation. The same defect of breaking up on firing and in transport led to its abandonment in the French artillery.

In 1872, the Navy Bureau of Ordnance instituted a series of experiments with gunpowder which were conducted with great success by the late Commander Marvin. The qualities of density and burning surface were established for all the Navy calibres, and the hexagonal grain, a device of the present Chief of Bureau, perfected and definitely adopted. The last named powder has the defect of all solid grains, (excepting Fossano) a decreasing burning surface, and, being nearly spherical in shape, the diminution is very rapid, being with the square of the radius, but this loss is more than compensated for by the low density of the interior layers. That portion of the grain which was joined with its neighbors in the same pressing, is very dense, and materially affects the gravimetric density.

In 1872, while attending at Fortress Monroe, some experimental firing for the Navy Bureau, the writer witnessed a series of trials, by an army board, with cakes or disks placed with intervening air spaces in the powder chamber, the cakes being in some cases provided with perforations in others without. The results were quite unsatisfactory however and showed great variation in pressure and velocity. This was due, again, to the half consumed cakes breaking up as in the case of prismatic powder.

In 1875, while stationed as Military Instructor at Amherst College, Lieutenant Totten of the Army devised and carried out a few experiments with a powder to which he gives the name of Compensating.

He proposes to enclose a gun-cotton sphere, 0″.5 in diameter, within a gun powder shell 0″.25 in thickness, the whole thus forming a grain 1″ in diameter. "This grain," says Lieut. Totten, "would be constructed with a scientific regard to the peculiar characteristics of each substance, and would evidently burn on the accelerating principle." Then, criticizing the navy hexagonal, and referring only to the decreasing burning surface and ignoring entirely the effect of the lighter density of the interior, the inventor claims that the 'compensating' grain would burn in concentric layers, the gunpowder portion insuring the start of the projectile, which at a safe instant would be followed by the more rapidly expanding products of the combustion of the gun-cotton.

A little friendly criticism from the Hexagonal side of the question will not be out of place, and it would seem that the following objections possess a certain validity.

Passing over the insurmountable objections with which powder makers regard all explosives more violent than their own, the well established tendency of gun-cotton to change its condition in a varying temperature, unless kept in a moistened state, the cost of its preparation, the question of the injurious effect on the health of workmen, the mechanical difficulties in getting the apple inside of the dumpling, and again in attaining the requisite high density in the outer shell, with a yielding, elastic pulp, like gun-cotton, in the interior, it would appear quite probable, that were all these objections eliminated, there would still remain more serious elements which would render the principle of questionable value:

1. With but a quarter of an inch of material in the outer shell it seems extremely probable that the structure would be crushed in by the first effort of the expanding gases.

2. Were the shell to prove sufficiently strong, would not the gun-cotton, confined in a medium, perhaps two thousand times denser than the atmosphere, develop unsafe pressures when exploded?

3. In Professor Abel's valuable contribution to the "History of Explosive Agents," published in vol. 159 of the Phil. Trans. of the Royal Society, we find the principles of the detonation of the nitro-explosives fully developed. After showing that gun-cotton cannot easily be detonated by nitrogen chloride, whilst this change is readily effected by a much smaller quantity of the weaker mercuric fulminate, and detailing a number of instances of this character all supported by experiment, Professor Abel concludes, "the vibrations produced by a particular explosive if synchronous with those which result from the explosion of a neighboring substance which is in a state of high chemical tension, will by their tendency to develop those vibrations, either determine the explosion of the substance, or at any rate greatly aid the disturbing influence of mechanical effect suddenly applied."

We have, in the Totten compensating grain, both of the elements referred to by Professor Abel. The explosion of gunpowder produces these vibrations, as we frequently hear of contiguous powder mills exploding without any communication by flame. The mechanical effect would be the impact of the powder gases against the solid remaining structure.

It is, however, a question in my mind whether Abel's ammonium picrate powder could not be used in some such manner as described by Lieutenant Totten. He would have here a substance of greater chemical stability, a solid which can be pressed into any form like gunpow-

der, less violence in explosion, and little liability to change of chemical condition with varying temperature. Experiment would be imperatively necessary to determine its capabilities in a detonating way. There would still remain the cost of manufacture, however, which, in all such matters, is a most important factor.

It seems doubtful, indeed, whether any of the nitro-explosives or their modifications can ever be utilized in a military way other than as bursting charges in shells, mines, or torpedoes. Their application to sporting purposes is being attempted, however, and we see in this country a preparation, called after its inventor, Ditmar powder, attaining a certain prominence. The polished interior surface of a fowling-piece barrel and the yielding character of the shot-charge and cardboard wadding lessen the *brutal* element in the quicker burning explosive, and, were it not for the occasional "unaccountable" accident, it might become deservedly popular.

Of the characteristics enumerated above, which affect the burning qualities of gunpowder, that of the density is the most important, and perhaps the most difficult to secure within required limits. The difficulty is due mainly to the variations in the hygrometric state of the atmosphere, and, although many suggestions have been made to secure uniformity in the amount of moisture incorporated with the mill dust, they have generally failed in attaining their object. The so called Wiener powder, the invention of Colonel Wiener of the Russian Artillery, differs in its manufacture from the ordinary variety in the fact that all of the moisture is eliminated in the press mill, the mixture here being brought to a temperature of 240° Fah., the melting-point of sulphur. In this manner, equal volumes of the product of the wheel mills can be pressed to equal densities, but the resulting grain (besides having a great capacity for moisture) would, on theoretical grounds, seem to be too violent in its action for modern rifled guns. This may perhaps account for the rather local reputation of Wiener powder.

Moisture performs the part of a cushion to lessen the violence of the explosion, the rôle of nitrogen when a mixture of hydrogen and atmospheric air is exploded, of the kieselguhr in dynamite, of pulp and sawdust in the Ditmar and Schultze powders, and of the chamber air space in the Spezia trials.

Again, considering the great specific heat of water, and remembering that the work done is proportional to the heat developed, the presence of moisture would, through this capacity for heat, have a direct and positive effect on the maximum pressure.

We will conclude our consideration of the modifications which have been proposed as improvements in gunpowder, with a description of the production of the Italian Mills at Fossano.

The abnormally high velocities obtained, coupled with moderate pressures, its adoption by several European powers, and its history in the remarkable trials with the 100-ton gun at Spezia, render it particularly interesting.

The manufacture presents certain peculiarities which, though suggested by the American Dr. Woodbridge some years ago, are to the general military public entirely novel.

After passing through the incorporating mill, the mixture is pressed into cakes of a density of 1.79. The cake is then broken up into grains of about one-eighth to one-fourth inch in diameter, which are mixed with a certain quantity of fine grained powder, and the mass again pressed to a mean density of 1.76. This second cake is finally broken up into tolerably regular grains about $2\frac{1}{2}$ inches in length and breadth by $1\frac{3}{4}$ inches in thickness, thus forming an agglomeration of two densities.

I have not seen the probable action of the powder gases from the Fossano grain discussed in any of the military journals, but surmise the sequence of events may be something like the following: It is found that relatively slight differences in density produce considerable variations in pressure, and, we can therefore assume, in the rapidity of burning. In a grain of this character then, the lighter powder would first ignite, and its gases, at a high tension, would, as it were, entirely surround the partially burned denser granules. The projectile has started and furnished greater space for the expanding gases, which is filled at once by the great store of energy (due mainly to its conditions of confinement in a dense medium), probably all developed in the same instant, of the heavier powder.

Such a grain would, in the earlier stages, for the same reasons of unequal densities, burn with an increasing surface, as inequalities or indentations would be formed, which would materially enhance its already decidedly progressive action.

Fossano has the great merits of cheapness and simplicity, and, if uniformity in the form and size of the grain can be assured, I see no reason why it should not have a great future.

Lieut. Soley. The paper which we have just heard is particularly interesting in that it shows how extreme changes in the action of powder can be effected by slight changes in the methods of manufacture and by varying the size and shape of the grain while the proportions of the ingredients remain the same. There are two points mentioned in the paper, in regard to which I disagree with the lecturer, though I do it with extreme diffidence, as I believe there are few officers in the service more thoroughly conversant with the subject of the manufacture of powder than he is; and I am quite ready to be corrected if I am mistaken. I was under the impression that, in the manufacture of the Fossano powder, the incorporating mill was only used for the preliminary mixtures of saltpetre-sulphur and sulphur-carbon, and that the process was continued by the use of mixing reels and hydraulic presses, an important feature being the fact that the incorporating mill is not used in the later part of the process. With regard to the Hexagonal powder, I am inclined to think that it somewhat resembles the Fossano powder, in that each cake is composed of large and small grains whose action would be very similar to that obtained with the Italian powder. I should have been glad if the lecturer had given some account of the Schaghticoke cubical powder, which has just been made the regulation powder for the large guns in our service, though I doubt if it is exactly a progressive powder, in the same sense as the Fossano is said to be. Any homogeneous powder of great density which may be considered as burning in concentric layers, is a progressive powder, in the widest acceptation of the term, and the velocity of combustion increases rapidly with the pressure developed by the gas, the diminution of the surface of inflammation being compensated, in the interior of the gun, by the velocity of combustion. The ordinary way of arriving at this result is by modifying the form and structure of the grain, and we have been told some of the methods of accomplishing this. Those powders which interest us most, in view of their actual or possible introduction into the service, are the Hexagonal, Schaghticoke, Totten's Compensating, and the Fossano; and I wish to consider the results of these changes on our ordnance.

An immediate consequence of putting armor on to vessels was the simultaneous increase in the weight of the projectile and the calibre of the gun; but, under these conditions, the fine-grained, quick-burning powder, which had been formerly used, was extremely dangerous to the piece, and it became necessary to modify the rate of burning. It is well known that when quick powder, under constant pressure, is burned, the disengagement of gas, at its maximum at the beginning, constantly decreases until the end of the combustion, giving its greatest force of disruption and translation before the inertia of the projectile is overcome. The experiments made by Rodman, Dahlgren, and others, on the pressures on the interior of the bore fully demonstrated this fact, and the results are expressed as follows:

| | | | | |
|---|---|---|---|---|
| At one calibre in rear of center of projectile, | | | | .98 |
| At center of projectile, | | | | 1.00 |
| At one calibre in front of projectile, | | | | .81 |
| At two | " | " | " | .68 |
| At three | " | " | " | .62 |
| At five | " | " | " | .53 |
| At seven | " | " | " | .44 |
| At nine | " | " | " | .40 |
| At eleven | " | " | " | .37 |
| At fifteen | " | " | " | .29 |

These figures show the relative strength necessary, at different parts, to resist explosion.

In view of these experiments, the well known Dahlgren shape was adopted, and has been adhered to not only in the small 8-inch and IX-inch smooth bores, but also in the 8-inch rifle and XV-inch smooth bores which

use some of these progressive powders; that is to say, powders which, on first combustion, develop a small amount of gas to overcome the inertia of the projectile, and, as its movement becomes accelerated, give larger and increasing gas pressures. The pressure curves of the quick powders and of the progressive powders show how the relations between certain parts of the gun and the strains exerted, have changed with the use of the progressive powders. Since the adoption of these powders has become a fixed fact in our service, and since we know that these new pressures will induce very different strains, the question presents itself with redoubled force, are we proceeding in the right direction in converting our smooth-bore guns into rifled guns which are to use progressive powders? In our 8-inch rifles which have been converted from XI-inch smooth bores, and which are being generally supplied to our ships, the cast-iron bore, which gave the gun its longitudinal strength, has been removed, and, in its stead, a coiled tube has been introduced, which is held in place merely by a small screw ring at the muzzle. The tube has only the longitudinal strength which it receives from the thoroughness of the weld; Armstrong was obliged to abandon the coiled tube A almost as soon as he adopted it, because he found that the bore of the gun must be the part which supplies the longitudinal strength; and, with the progressive pressure of the new powder, these guns of ours are weakest, both longitudinally and transversely, where they need the greatest strength. The lamentable disaster on board the *Thunderer*, whether the result of accident or carelessness, while it calls forth all our sympathies, must, at the same time, be instructive. An inspection of the diagram of the burst gun shows that it went in the very place where its comparatively small longitudinal strength was supplemented by the least transverse strength. As long as we confine ourselves to twenty or twenty-five pound charges, in our 8-inch rifles, there is no particular danger, but, if it becomes necessary to use these guns in action, with thirty five pound charges of progressive powder and battering shell, I venture to say that our makeshifts will make us regret that they were ever introduced.

Lieut.-Comdr. FOLGER. If I understand the question raised by Lieutenant SOLEY, as to the fact of the incorporation of the ingredients of Fossano powder, I do not exactly see how the necessary intimacy of mixture for perfect combustion can be obtained without the passage through the wheel mills. Were we to manufacture Fossano in this country, I hardly think the requirements of the Ordnance Bureau would be satisfied with any omission of this kind. The Schaghticoke Cubical is merely the mammoth grain in regular forms. If it were a flat grain instead of a cube, it would be more effective, as the surface would not diminish so rapidly in combustion. The regularity in shape is obtained by grooving the press cake in the desired lines of fracture. The homogeneous density, I consider, viewed in the light of the latest ideas on powder, is a defect rather than an advantage.

The Navy hexagonal is not a pressing of two densities, but simply of the product of the wheel mills. Of this I am quite positive, as I was present at the original experiments, in a manufacturing way. I think the present grain is too small for an application of the Fossano principle.

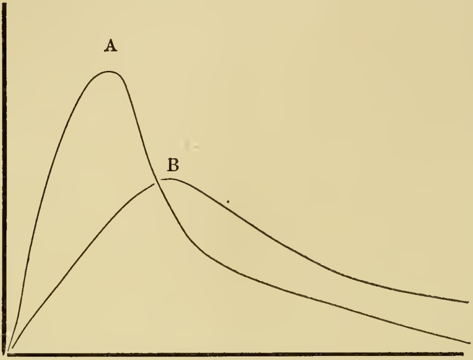
The converted XI-inch gun is not by any means a model arm in its curves and lines of resistance, and of this I think none of us are more convinced than is the Bureau of Ordnance. I must, however, disagree with the gentleman in his opinion, which we are led to infer from his remarks, that it has little or no value as a part of the armament of our ships, or is so defective in its lines of resistance as to possibly be even an element of danger to our guns' crews.

Merely referring to materials, it is an acknowledged fact that American iron possesses more of the qualities requisite for gun-making than any other iron in existence; and, made of iron, these guns have withstood

pressures in proof-firing of from thirty thousand to sixty thousand pounds per square inch.

Now, whilst the highest pressure ordinate with a progressive powder is somewhat further forward than with the quick-burning varieties, it at no

Fig. 3.




time reaches their dangerous limits (Fig. 3), and at the moment the projectile is passing the weaker points in the gun-cylinder referred to by the gentleman, the curve is doubtless falling rapidly by the movement of the projectile. Should the shot jam, as was first reported of the *Thunderer's* accident, there are good reasons for believing that no system of artillery can withstand the strain.

If we now utilize this capability of resistance of sixty thousand pounds' pressure with the latest ideas on progressive powders, as the Chief of Bureau intimates, in his last Report to the Secretary, that he is prepared to do, we have a powerful addition to our ships' batteries, and one which should inspire self-congratulation rather than any other sentiment, when compared with our antique smooth-bores.

We are not proceeding in a wrong direction, for at this moment the Bureau of Ordnance (which all along has presented the 8-inch rifle as a makeshift to tide over an economical Congress) has prepared drawings and specifications of a 6-inch and a X-inch steel gun, to be undertaken with the first funds appropriated for the purpose. Our makeshift 8-inch rifle has been paid for by the sale of condemned material; it costs but $2,000, while the X-inch steel gun will cost more than twenty times this amount.

Lieut. Kennedy. In Professor Hill's lectures on explosives delivered at the Torpedo Station, I find the statement, that when powder is pressed, if it be too dry it will not bind or retain its form; and if too moist it cannot be much pressed on account of the incompressibility of water. Without going to either of these extremes, the density of powder may be greatly varied by a slight change in the moisture contained. In the Fossano powder mentioned in the paper just read, the powder is first pressed to a density of 1.79 and then broken up, mixed with other powder, and again pressed to a density of 1,776. These limits are very small, and still on this difference depends the progressive action of this powder. How is the moisture kept at exactly such a point that the same pressure shall always produce the same density; and, in general, by what means is the moisture

controlled during manufacture, particularly in damp weather, so that different lots of powder shall always come up to the required standard?

Lieut.-Comdr. FOLGER. As I intimated in my notes, it is a matter of considerable difficulty, to reproduce densities, and I have repeatedly seen the production of the work of days thrown back on contractors' hands as showing too great variations in density. The Bureau usually limits the manufacture to 0.01 on each side of the required point, and this they consider very close work. The matter requires the greatest care, and experience alone is the best guide. The hygrometric state of the atmosphere is noted and the quantity of water added in the wheel mill is regulated accordingly. The behavior in the press, the sounds given out by the mass at the close of the process, in connection with normal marks on the press frame are among the points which govern the judgment of the pressers.

It is remarkable however what experience or good judgment will sometimes accomplish in this respect. I witnessed the manufacturer's inspection (Oriental Mills) of an army contract last year in which with twenty densimeter samples the extreme variation was but 0.007.

Lieut. MILLER. I should like to ask if the lecturer considers the Rodman cutter a reliable instrument for measuring the pressures which take place upon the explosion of the charge.

There are many instances where the indentations upon the copper disk have recorded pressures far beyond the tensile strength of the gun metal. Last year at the Experimental Battery, the XI-inch gun was loaded with service charge and shot—the powder being that known as oriental cannon, which I think had been twice reworked. The pressure indicated was on one occasion as high as one hundred and fifty thousand pounds, and on others about ninety thousand. Now the tensile strength of the very best cast-iron is never over fifty thousand pounds per square inch.

Therefore were the enormous figures quoted above due

I. To an error in the Rodman cutter itself,

II. To the non homogeneousness of the copper disk, or

III. To the effect of gas waves reacting from the base of the shot, acting as *successive* blows to drive the knife deeper and deeper into the disk?

I am well aware that the opinion is held that if it requires a force, say of forty thousand pounds, to drive the cutter a sixteenth of an inch into the copper it will require a greater force than forty thousand to drive it any further at any subsequent time, but it strikes me that the theory is not altogether correct; especially as regards the action of explosive gases in a confined space, and I would especially ask if the resultant cut in the copper, may not be the combined effect of several pressures, acting at different times and each less than that necessary to rupture the gun.

Lieut.-Comdr. FOLGER. If I remember correctly, General Rodman believed his method of measuring pressures to be reliable within one thousand pounds per square inch, even at the maximum, but my own limited experience would lead me to a contrary opinion, at least as regards its measuring absolute pressures. There should be some account taken of the time element, for, with the testing machine, the particles of copper have a chance to "flow," or in other words, arrange themselves.

Again, we are taught, considering the metal homogeneous, that the resistance to the cutter varies with the square of its velocity.

The pressure of a hundred and fifty thousand pounds per square inch referred to was probably the total of a number of *local* pressures, which always occur, according to a number of writers, (particularly with a quick burning powder,) and which are unquestionably due to the wave-like vibration mentioned by Lieutenant MILLER. This action of the gases probably continues during the whole of the interval occupied by the shot in its passage to the muzzle. With a uniformly-burning progressive powder, the Rodman gauge will register much nearer the true pressure.

As regards the point referred to by Lieut. MILLER that the XI-inch gun did not burst with a registered pressure much beyond the tensile strength of

iron, I think the terse remark of General Rodman concerning such cases, that it "did not have time to burst" (before the pressure was relieved) is applicable. Also, we might say, the case is analogous to the simple experiment of the breaking of a small iron wire. A sudden jerk will not effect a rupture whilst a continued effort in which much less force is expended will accomplish the object. Tensile strength is measured by the slow process.

The mathematicians have demonstrated the fact that a homogeneous inelastic cylinder will burst if the internal pressure per unit area exceeds the tensile strength of unit section, but in our case the limit of elasticity of our unit section is not reached with its rupturing pressure, as measured by the testing machine, The curve of resistance falls very rapidly however, and we reach a point beyond which no increase in thickness of metal will add strength to the gun cylinder.

The point of the non-homogeneous character of the copper disks enters largely into the question, and is doubtless a frequent cause of unreliability in the registered pressures. This fact was one of the strongest arguments in favor of the adoption of the spiral gauge, as the copper disks used with the latter are much smaller, and variations in hardness and density do not produce so marked an effect.

The Chairman. I have listened with extreme interest to the able paper which has just been presented to us, and I find in it nothing to criticise and feel that there is little to be added to it. It suggests, however, one or two thoughts.

The lecturer has pointed out certain objectionable features in the Totten powder which would interfere with its use. Besides these, there is another which is quite as important. It is well known that explosives such as gun-cotton and nitro-glycerine, if ignited when exposed to the atmosphere, simply burn freely; but if ignited when they are closely confined, they explode with detonating violence. When the Totten powder burns in the chamber of a gun, we have the gun-cotton ignited while it is closely confined, and it is quite probable that a detonating explosion would result.

I have been pleased to see that the lecturer places more reliance on the pressures as determined by Rumford and accepted by Piobert, than on those obtained by later experimenters, and I am disposed to follow him for several reasons. First, because, as he has pointed out, Rumford is the only experimenter who has directly measured the pressure. Second, because I have yet to learn that it has been shown that Rumford's apparatus was defective, that his method was faulty, or that there were any errors of observation in his experiments. The chief objection urged against his measurements, is that the results did not agree closely enough among themselves, but Noble and Abel have shown that closely agreeing results can only be obtained when the different specimens of powder are of normal type and uniform make, and it is doubtful whether Rumford possessed such powders. In the case in which Rumford estimated the pressure under which his gun burst, there can be no doubt that his results were too high, and there is no question that the fact of his having done this, and attempted also to explain the high pressures obtained in all the experiments by an erroneous theory as to the action of aqueous vapor at high temperatures, has done much towards throwing discredit upon all his work. Between the results of Rumford and those obtained by Noble and Abel, there is a difference so great that it is difficult to explain it. These last pressures having been obtained by calculation, and by comparison of the calculated pressures with those obtained by the crusher gauge, are more likely to be in error than those obtained by direct experiment. The fact that estimates by the two methods agreed closely, confirms me in the belief that they are too small; I agree with the lecturer in believing that the crushing machines register too low a pressure. To calculate the pressure exerted by powder, we must know the quantity and character of the products of its combustion, the temperature of combustion, and the action of the products at the high temperatures which ob-

tain in the experiments, and, notwithstanding the interesting investigations of Bunsen and Schischkoff, and the more elaborate researches of Noble and Abel, I do not think that these data have yet been determined with sufficient accuracy.

I would like to ask the lecturer how he accounts for the increased velocity and diminished pressure obtained with a small air space, and also the action of the gases with a large space, as for instance, when the projectile has slipped forward.

Lieut.-Comdr. FOLGER. There are so many opinions and theories on this subject since the *Thunderer's* accident, that I fear one from myself will throw no additional light on the subject, but I believe the action of the gases to be something of this character:—

When the projectile is pressed close against a charge which entirely fills the chamber, the latter burning more rapidly in a confined space develops a greater portion of its energy, in a given time, than when air space is furnished. With a limited air space, a smaller portion of the charge overcomes the inertia of the projectile, leaving the remainder to develop a progressive action on an already moving obstacle. This perhaps accounts for the increased velocity. Concerning the reduced pressure, we have the same argument of less powder burned in a given time, and to go into details, I think the cushioning effect of the air particles assists in starting the projectile when the space is small. Perhaps a portion, at least, of the oxygen in the air is utilized in combustion, though that from the saltpetre is, the chemists tell us, more apt to perform this part of the work, but there still remains the nitrogen. Again, the air particles would use a portion of the energy in their own rise in temperature.

With a large air space, the cushioning effect, more apparent, permits the entire combustion of the charge before the projectile starts, and the developed gases being given direction by the tube—focus, we might say,—with great inertia on a projectile at rest, and a rupture of the walls of the gun is the possible result.

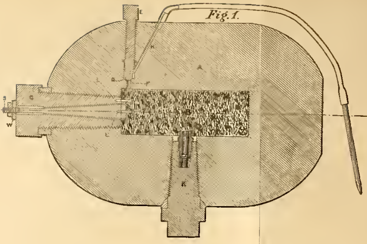



*Fig. 1.*

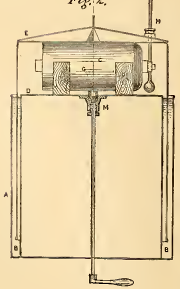



*Fig. 2.*

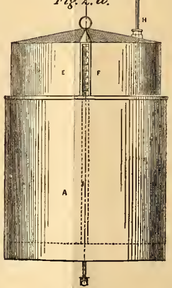



*Fig. 2. a.*

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UNITED STATES NAVAL INSTITUTE.

NAVY DEPARTMENT, WASHINGTON,

FEBRUARY 13, 1879.

Vice-Admiral S. C. ROWAN, U. S. N., in the Chair.

# THE PURPOSES OF A NAVY, AND THE BEST METHODS OF RENDERING IT EFFICIENT.

BY REAR-ADMIRAL DANIEL AMMEN, U. S. N.

At the time of the receipt of the invitation of this Institute, I had agreed to prepare a paper for publication in "the United Service" quarterly, which I have the honor to read on this occasion, relating to the subjects which engage our attention.

The purposes of a Navy are more complex, important, and constant than are supposed by persons who only regard it as a means of offence and defence in war, and who are ignorant, in a great degree, of the training necessary to efficiency. Many suppose that in time of peace we need no Navy; that, should a war occur, our merchant marine would supply us amply with officers and men, and as well with vessels, which, with the mere addition of fitments of armaments and appliances, would become formidable vessels-of-war. It is intended to show the important, not to say the indispensable functions, performed by the Navy in time of peace; and, as well, that a Navy cannot be improvised, capable of meeting an enemy having a *personnel* more thoroughly trained and disciplined, and provided with vessels built actually for war purposes.

A farmer surrounded by lean and hungry stock ready to overrun and feed upon what was not hedged around, would be thought foolish were he to try to raise a crop or even graze his own stock undisturbed, without in advance planting his hedges. In vain would he endeavor to supply the deficiency when his enemies were upon him.

The nation that would establish no carefully devised system of de-

fence against aggression from within and without, would be no wiser than such an improvident farmer. The Army and the Navy are the hedges of a nation, more or less properly planted and sustained, and are no less indispensable to a nation's security and prosperity than the hedges to the farmer. I hope to show that they do not occupy ground idly or unprofitably; that they bear their fruits,—none the less valuable to the nation because they are, as it were, common property.

There is hardly a projected "Internal Improvement" throughout our wide territory, that has the shadow of national importance, that is not planned, if not superintended in its execution, by the Engineer Corps of our Army. There is not a menace to public order, or a riot whose object is plunder, where the humble Infantry soldier is not hailed as the useful and timely friend to the "man of good will," be he rich or poor.

You hear it said that these outbreaks should be met by "citizen soldiers,"—by the volunteer or the militia-man. The employment of such forces, without the aid of United States soldiers or of sailors, in the riots of July, 1877, was, at no one point, satisfactory; wherever there were disorders and no United States forces present, there was great destruction of property, entire insecurity of life, and especially to the luckless wight who stood as a volunteer or militia-man, the guardian of the lives and property of his fellow citizens. The wrath of the mob knew no bounds against him, when, at the same time, the forces of the United States were not assailed, and their presence and authority were respected. It seems to me that the lives of our citizens are of too much value to make them the targets of the blind rage of the mob, of the men who, under pretence of being laborers without employment, are disposed not to labor except upon their own demands, and to violently prevent others from laboring, yet quite willing to gain what they can by violence and robbery.

I beg your pardon for apparently wandering from the subject which is designed to be discussed,—that of the purposes of the Navy, the services of which, at the time referred to, were not without value. The soldier and the sailor were alike recognized as the friends of "men of good will," and their presence and their authority were respected by the mob.

The operations and objects of a Navy are mostly afloat: on the high seas the navies of the world form a common police, without which life and property would be wholly insecure. The nation that, in time of peace, should disregard its obligation to perform its part of a common duty, would, in time of war, suffer disadvantages and losses which

would be incalculably greater, arising from a want of preparation for defence and aggression. The spirit of piracy exists now, as ever; there are no pirates, or rather piracy is rare, simply because the seas are policed by the navies of the world.

There are other purposes also, in time of peace, which employ the active energies of the Navy. As an example, we may refer to the Expedition of Commodore Perry to Japan, in 1854. This event is so recent that it seems hardly necessary to more than mention it. Had this Expedition not been sent, or had it been less ably commanded, it is altogether probable that the Japanese would still be an isolated people instead of occupying a distinguished position among the nations, due to their high character and ability, and to their great artistic taste. Let it not be supposed, by those not conversant with the history of the Expedition, that it was used as a force to bring about commercial relations. It was, in fact, rather a formal exhibition of the appliances and advancement of European civilization, and a demonstration of the advantage which peoples derive from a free intercourse, not in matters of trade solely, but even, in a greater degree, to the speedy dissemination of knowledge, due to the aggregate gains of many races and nations.

The only demand made by that Expedition was the right of refuge in Japanese harbors to our vessels suffering shipwreck or injured from stress of weather, on their coasts. The Japanese were informed also that, whilst the government of the United States desired commercial intercourse, in the belief that it would be mutually advantageous, it recognized the fact that, even when allowed by treaties, it could only exist when it was found to promote the interests of both parties. Thus thirty-five millions of industrious, intelligent and highly ingenious people were added to the family of commercial nations, due wholly to one of the purposes of a Navy,—a fact at variance with the assertion that we have no need for a Navy in time of peace.

This Expedition, so ably commanded, was engaged in making all possible surveys to render navigation safe in those comparatively unknown and unvisited seas, and in pursuing a vigorous routine of training to officers and men, which was of the highest value in promoting the efficiency of the Navy. It was, in fact, the commencement in our naval service of a more methodical and thorough training, that had become necessary through the use of steam as a motor, and the improved armaments on board ship.

About the same time, one of our vessels-of-war visited Paraguay, made a survey of some two thousand miles of the river Parana and its

affluents, and did much to bring that nation, then isolated, into common relations with commercial nations.

By our Navy officers the river Amazon has been explored from its head waters to the sea; and now that magnificent stream is navigated its entire length. Only last summer, hundreds of miles of the river Madeira, one of the affluents of the Amazon, was admirably surveyed by one of our vessels-of-war, which will serve, ere long, to enlarge the commerce of that region, with our own and other nations.

Within the past eight years the Navy has completed surveys wherever required,—of the water-sheds of inter-tropical America, from Tehuantepec to far up the waters of the river Atrato, leaving nothing in doubt as to the solution of the Inter-oceanic Canal question across this continent. It has, at the same time, determined by telegraphy, with extreme accuracy, the longitudes of many important points in the West Indies and on the eastern coast of South America, and has sounded two lines across the wide Pacific, and one from San Francisco to Australia, to facilitate the laying of marine cables in the future.

The two large Expeditions to the Pacific, the one commanded by the late Rear-Admiral Charles Wilkes, and the other by the present Rear-Admiral John Rodgers, require mention,—the valuable surveys made by them, and the civilizing influence which the visits of those Expeditions exerted over the many savage inhabitants of the Pacific islands.

It will be remembered too that our Navy did much in examining the route for and in laying the first cable between Europe and America.

Surveying the oceans, with their innumerable islands, rocks and hidden dangers, is the legitimate duty of the navies of the world, and, I may add, necessary to the safety of the commerce of the world. Unless this is done by them, it will remain undone forever; hence, it should be regarded as a duty in common. From its magnitude, it is a work of many years, if apportioned out by agreement between the nations themselves; and, when the whole field has been covered, from the constant physical changes, much of it would require re-survey, making this duty, in fact, interminable.

Our Navy has furnished inspectors of light-houses and officers for the hydrographic duties of the Coast Survey, both of which are of great importance to our commerce and to that of other flags visiting our coasts.

I was reminded, by an intelligent friend, of the great advantage derived by our merchants in many foreign ports, through the appearance, occasionally, of a vessel-of-war, especially in such countries as

have unstable governments. A cursory examination of a Chart of the Globe will show the very great number of ports of this character, and the necessity of protection, beyond a " moral support." On two occasions, during a brief period, when I was Acting Secretary of the Navy, after conferring with the State Department, it became necessary to state with precision, through our Naval commanders, what was expected on the part of the Powers concerned; the response to which was prompt and satisfactory. Such have been the purposes of the Navy, more or less, since its formation; such will be its purposes, more or less, as long as it is efficiently directed, and as long as it exists in a state of efficiency.

The actual knowledge required to make a useful officer of the Navy is diverse and considerable; and the training, special and onerous, can only be acquired by encountering the vicissitudes of the sea in varied forms, over the wide expanse of the navigable waters of the globe; nor would this experience suffice without previous careful primary instruction. Every vessel-of-war, properly commanded, is a school of instruction; in every sea vessels-of-war are or should be engaged in making partial or extended surveys; in sounding out the depths of the oceans, and, as before stated, in maintaining the police of the seas, without which there would be no security.

At the breaking out of the Civil War, the Prince de Joinville, who was conversant with our naval training, expressed a very favorable opinion, which was published at that time, as to the efficiency of our Navy. He stated that our people would not be disappointed, so far as its operations were concerned. I will leave to others the expression of an opinion on this point, but call attention to what was anomalous and difficult in connection with those naval duties, and their results. Hundreds of officers were appointed from the merchant service, many of them having excellent qualities, and knowledge as seamen, who readily learned the routine of naval duty, and how to manage large numbers of men effectively, on the deck of a vessel. They fully appreciated whatever was effective in the routine of the Navy, and soon had practical experience in fighting ships and batteries, and the methods of instruction of the crews adopted and carried out most effectively by the ablest officers of our Navy. I feel sure that our officers, in general, will take pleasure in acknowledging the high character and professional ability of some of these officers, which would make them a creditable accession to any Navy List.

A certain number of these volunteer officers, less gifted in the pos-

itive and special qualities which belong to the able officer, were less useful, and to a certain extent were disposed to depreciate what they could not comprehend nor attain. It need hardly be added that these officers were in general inferior in proper conduct, without which effective officers cannot be made, however gifted they may be otherwise. The volunteer officers called into the service were many times more numerous than the officers belonging to the regular Navy; and such would doubtless be the case again should we have a war with a great naval power. Hence the necessity of having a sufficient number of well trained officers in the Navy to meet the exigency which must arrive, that is in fact only a question of uncertain length of time with every nation. It would be impossible to conceive in advance the mass of confusion, of ill-directed effort, of mis-spent money, of national calamity and disgrace which would ensue were we to act upon the supposition that a Navy was of no use in time of peace, and could be effectively improvised in time of war.

However able, as seamen, those of our merchant service may be, and however gifted in character, as a class, they would require special training to enable them to effectively direct and control the operations of large numbers of men, in which they have no experience in the merchant service, and in the appliances and use of heavy ordnance, in itself requiring aptitude on their part, as well as considerable experience in gunnery on board vessels-of-war of the officers who might be detailed as instructors.

In this connection the latent force that a nation possesses, existent and ever ready in a large retired list of competent officers becomes apparent. The government of Great Britain so fully appreciates this, and the importance of promotion at a proper age, that to effect these objects several methods of retirement are offered. A Rear-Admiral may retire at his option at fifty five years of age; a Captain at fifty; a Commander at forty-five; and a Lieutenant at forty; but when five years are added to their respective ages, retirement becomes compulsory. If however, an officer has not served for five years in some of the grades, or seven in others, whatever his age may be, retirement is compulsory. Under such regulations it is difficult to suppose that an objectionable or incompetent officer can be continued on the active list; and it is apparent also that some officers at least of those grades, of high professional worth and unexceptionable character must be retired without a suspicion even of mental or physical infirmity. A position is made for advancement on the retired lists carrying with it substan-

tial benefits, establishing plainly the purposes of these compulsory retirements, which are indeed fairly expressed in the order.

The advantage derivable to a Navy from officers attaining responsible positions in command before they are too old, is a marked feature of the British system of retirement and promotion ; indeed, it is fairly the object of retiring the officers at the ages stated ; an officer kept too long in a subordinate position loses, after a certain time, the ability to bear what is known as responsibility ; and after that, whatever his character and professional attainment may be, he lacks an essential element to usefulness in a high grade. Our system of retirement, or rather of replacement on the active list, through legislation, of officers who have been lawfully retired, seems calculated to seriously impair the efficiency of the service ; officers of the higher grades of the best character, and who have rendered the best services afloat in the line of duty, pronounce upon the merits and professional qualifications of those who have become eligible for promotion by seniority. It would seem most difficult if not impossible, to name another tribunal that would as well guard the interests of the government and also that would be disposed to consider and protect the reasonable claims for advancement to the officers. It is usually assumed and asserted by those interested that an officer has a "right" to be promoted, and that great injustice is done when he is passed over or retired.

I suppose there exists entire unanimity of opinion among the officers present that our government should consider strictly its own interests in setting aside those officers who, from whatever cause, are not efficient, even though the disability should be from wounds received in action and the officer himself be a brilliant exemplar. It is presumed however that his merits have justly won and entitle him to a retired pay proportionate to his rank and his professional worth in the past. It is an injustice to consider that an officer not recommended for promotion, and who under present laws will be retired, may not have excellent qualities, and may not have done excellent service.

I will venture to say that there is not one among us, of the older officers at least, who has not a high personal regard and a warm friendship for many brother officers who have been compulsorily retired, when he believes too that the best interests of the service required such action on the part of the retiring board. The intelligent discussion of this subject by the Institute will not fail to show whatever difference of opinion exists among its members, and it will serve to enlighten our friends on a very important point.

During a period of more than six years in charge of the Office of Detail, a position advisory to the Secretary of the Navy in making assignments to duty, as all present are aware, I have no recollection of any senator or member of Congress pressing a recommendation for orders of any one against the reasons given, when fairly expressed and understood.

Nearly if not all of the legislative difficulties respecting the Navy grow out of expressions of opinion on the part of ourselves, either crudely digested, or arising from personal or partial views and motives, through which a part of the Navy or its interests, is presumed to be greater than the whole. If we can agree among ourselves and present fairly the questions that belong to making the Navy efficient, to and through the Navy Department, I think there will be no difficulty in attaining a satisfactory end so far as legislation is concerned.

In relation to the adaptation of vessels built for the merchant service to the fighting purposes of a Navy, it may be said that there is not one in a hundred that, with the same displacement, would stand an equal chance in a naval engagement with the best types of vessels built for fighting. In general, inferiority of a vessel, in time of war, results in her capture, instead of capturing her enemy. The result is altogether more serious than inferiority in the ordinary pursuits of commerce, especially when it is one of speed, and perhaps due to no greater difference than having a fouler bottom.

It may be assumed that all sea-steamers hereafter built for our merchant service will have compound engines with the boilers, and the steam connections placed so high relatively, with vessels built for war purposes, as to make the chances of striking them with shot or shell far more probable, and thus increasing the chances of disabling the vessel. There is a popular error that compound engines give increased speed, when, in fact, they only effect economy of fuel when a vessel is kept at a high and uniform rate of speed. A vessel thus furnished has a conditional advantage of economy in fuel, advantageous in the ordinary pursuits of commerce, and, on the other hand, with disadvantages, for a vessel-of-war, in having more liability to breakage from an increased number of working parts, with whatever disadvantages may exist in being compelled to carry a high steam pressure to attain a fair speed. Whatever may be thought of the effect of an explosion of boilers for compound engines, so far as the safety of the hull is concerned, or of the relative scalding effects on the crew between decks, with boilers having less steam pressure, in either case when the shell of a

boiler is pierced, all of the heat will escape instantly to the boiling point, and as well of the water, which, owing to the increased pressure, is much hotter in the boilers of the compound engine than in those of the ordinary low-pressure, considered with the normal speed. The view here presented, so far as concerns the relative values of compound and ordinary low-pressure engines for vessels-of-war, corresponds with that of a very capable officer who has commanded vessels having compound engines for several years, and who has a practical familiar knowledge of the ordinary low-pressure engines also, such as are common in vessels-of-war.

No wooden propeller steamers of any size are built, except on this continent. A want of rigidity of frame, not of course demanded for the safety of the vessel, but for the security of the engines against bad lineage, and consequent frictions, heating of parts, and then break-downs, makes them inferior to iron vessels when the latter are "sheathed" or are "composite,"—neither of which are common in our merchant marine, if they exist at all, and are not likely to be built for the merchant service, as their construction would be more expensive than the ordinary iron vessel.

There is no "composition" or paint known, that will prevent the fouling of the iron bottom of a vessel; and that too so speedily that a month passed in inter-tropical or warm waters would so reduce the speed that a sheathed and coppered vessel of the same model and power would either overtake or run away from her, as might be desired. It follows that vessels with iron bottoms would be unsuccessful in capturing those with coppered bottoms, and, on the other hand, would be liable to capture, from a comparative want of speed, under the conditions that are unavoidable to cruisers.

There is another point fatal to the use of unarmored iron ships, and not "sheathed," for fighting purposes. Whilst a shot or shell enters them without special damage, when passing out on the opposite side it usually disrupts or tears off a whole sheet of plating, making it impossible for the vessel to be kept afloat when so injured. This was shown to be the case in the attack on Fort Obligado, on the river Parana, above Rosario, in 1845. The same result was shown in the sinking of the *Hatteras* by the *Alabama*, and so quickly, too, that, although the water was smooth, there was barely time to transfer the crew to the other vessel before the *Hatteras* went down.

In short, the merchant steamer of to-day, with us, is not even well adapted to pursue and capture the commerce of an enemy,—certainly

not, if the bottom be of iron exposed to the action of salt water, from the rapid loss of speed before alluded to, through fouling. Not only is the bottom soon covered by oysters and barnacles, but with a wonderful vegetable growth, much like a thrummed mat applied to the bottom of a ship. So far as fitting them in any manner to meet vessels of war of equal tonnage successfully, the average result would prove entirely disastrous.

The war purposes of our Navy demand at least the protection of our inland waters, such as Long Island sound, and our great bays, as well as the immediate vicinity of the entrances to our principal harbors so that no enemy could feel secure in those localities. We should also be able to send on the high seas, along the great routes of commerce, vessels capable of greatly injuring the commerce of our enemy; and no types of vessels could do this more effectively than the classes which we should build and send abroad in time of peace to police the seas, to serve as schools of instruction, and to carry out the other purposes of a Navy, which I trust have been shown to be substantial, indeed indispensable to the best interests of a great commercial power.

As for "convoys" and "blockades," we may suppose that they will be rare indeed; a convoy requires long and vexatious delays, and, in transit, a relative low rate of speed, which would make protection altogether doubtful. A blockade of a port, or even many of them, would only increase railroad transportation with us; the blockade of the ports of any country of Europe, even if considered possible, would seem only to make supplies of whatever kind arrive through the ports of friendly adjacent powers, and to transportation by railroads.

There is so much diversity in the recognized weapons of naval power, and such a diversity of models, of the means of propulsion, and of displacement of vessels-of-war that will directly antagonize each other in war, that a great diversity of opinion must exist even among those best informed concerning them and their relative fitness for destruction,—the end in view. Those instruments, whether simple or complex, which will effect the best and most satisfactory results at the least cost, are those which are the most worthy of adoption. Unless the end be kept rigorously in view, the consideration of the subject becomes ideal and intangible.

I venture the opinion that the time is not distant when the Marine Ram will take the place of the enormously expensive armor-plated gun-bearing ships of to-day, and when iron framed steamers, "sheathed" and "composite," with good sailing and great steam pow-

er, will form the cruising naval force, supplied with such aid as may be desirable from movable torpedoes, whether carried in torpedo boats guided by a crew, or like the "fish" torpedo, left to their own guidance when released.

I am quite aware of the existence of a strong prepossession on the part of many officers for wooden-built ships, and recognize some points of superiority which they possess, particularly in battle. Without entering into a close comparison between wooden-built vessels-of-war and iron vessels of the "sheathed" and "composite" constructions, I think that past experience has shown that hitherto constructors have failed to give the necessary rigidity to the frame work of wooden propellers having long shafts, and hence the impossibility of driving them at a high rate of speed for any length of time without a break-down. The iron frame and sheathing of iron vessels when sufficiently heavy, and built with a proper distribution of metal, is practically rigid; whatever the unequal distribution of weights in sections as compared with their displacements, no change of model will occur, at least within the limits imposed by the distributions of weights, with ordinary batteries and other conditions required for vessels-of-war.

While the first cost of the "sheathed" and "composite" vessels-of-war will be slightly greater than that of wooden vessels of the same displacement, at least until we have a proper "plant" for their construction and experience in it, they will doubtless be found far more economical when the time for repairs arrives. When the frame of a wooden vessel requires repairs to any extent, the cost becomes actually greater than the construction of a new hull, and the result quite unsatisfactory, as the vessel is serviceable only for a short time, and then, is added to that long list of disabled or partially serviceable vessels with which our Navy is unhappily filled. On the contrary, the vessel having an iron frame is readily repaired at a comparatively small cost and then becomes substantially a new vessel.

I doubt not that so far as what has been said relating to the purposes of our Navy will be supported by the observation and experience of every one conversant with the subject; and that much more could be said of great weight in support of its necessity as a peace establishment. On so broad a subject as the best methods of attaining naval efficiency, and as to the classes of vessels and the implements required, there must necessarily be wide differences of opinion. The very many changes that have occurred in naval architecture in the past half century are quite remarkable, and there seems to be no reason to suppose

that we have reached the models and constructions that will stand the test of time, or that we now have the enginery and armaments of permanent adoption. It seems worth while for us neither to be fixed in the idea that we have reached a state of comparative permanency, nor on the other hand to expect to rely upon supposititious and untried developments of naval strength. The time of peace, however, is the time to design and test whatever seems calculated to make naval warfare formidable, destructive and economic, remembering that nothing is economic that is not effective.

So far as the *personnel* of our Navy is concerned, relatively with that of other powers, I think that we may feel satisfied. Considered physically, mentally, morally and professionally, I think our officers are not surpassed by those of any other Navy. After a careful selection and training at the naval school, and during "practice cruises," comes the practical instruction on board of a vessel-of-war, with its fatigues in watches, drills, labors and experiences which teach. There is perhaps no training more calculated to give vigilance and coolness in peril than that of naval life at sea. Every day brings its alarms, feigned or real; the alarm of fire without previous warning awakes the sleepers, and only after all of the preparations are made to extinguish it, the ordinary result shows it to have been an exercise. Fierce winds sweep suddenly across the ocean, and vigilant indeed must be the officer who is not at some time "caught napping." The life is one of intelligent routine, and at times an earnest struggle for existence itself, and that too when the dangers of war do not exist. Courage is a natural quality, far more common than many suppose,—at least, sufficient courage to do a recognized duty; but that alone will not suffice. That eminent divine, the Dean of Westminster, said, "Courage, self-control, discipline,—these are the gifts by which victories are won on earth." These are golden words: if they are taken to heart by our young officers, we have nothing to fear afloat from the power of any adversary.

Comdr. WILLIAM GIBSON. Mr. Chairman and gentlemen: I have listened with the greatest pleasure, as we all have, to the able and interesting paper we have just heard from Admiral AMMEN; and I am sure he will pardon me if I call attention to what, I think he will agree with me, was inadvertently omitted from that paper,—namely, a reference to the duties of the Hydrographic service. It is simply impossible to exaggerate the importance of that service. The men-of-war in time of peace cannot be better employed, it seems to me, than in marking out the ocean highways, in tracing the perilous lines of coast, in scouring the harbors, in marking the lurking shoal and the bold reef. These duties belong to the Hydrographic Office, and none are more important in the range of the Naval service. These charts, prepared by the Hydrographic Office, take away from us the terrors of Charybdis, and save us from the jaws of Scylla. You, Mr. President, know that in doing this work, our brave men often carry their lives in their hands, and you will join in the sentiment and regret that, to the noble army of martyrs in this field, headed by Cook and La Perouse, must now be added the name of William King Bridge, commander and representative of the unfortunate brig *Porpoise*. Of him we question the great deep, and there is no reply.

But it is of the Hydrographic Office I would speak. This Office is at present organized and is in the way of its enlarged and ever enlarging sphere of usefulness. It is the center and source of all this work. Under its auspices vessels are despatched on their errand of usefulness; for it is necessary to do this work on the field, and charts must be constructed from the actual surveys they make, for the benefit of all our ocean travel. And, gentlemen, how interesting and beautiful is this chart-making! How wonderful to watch the working sheet—the chart growing into shape and recording, in unerring lines, the results of the skill and pains-taking labor of the brave men in this service! How full of interest to trace the growing lines from peak to peak, from headland to headland, and from point to point, covering, as with an aerial net-work of triangles and curves, every square yard, as it were, of the ocean's floor. These charts, thus made, by the Hydrographic Office are not only furnished to our men-of-war, but are given to the world. They are sold, I believe, to the commercial marine, for the cost of paper and printing alone, and they are of incalculable value. A more valuable service could not, I believe, be rendered to the commerce of the world than the making and publication of these charts.

As an illustration only, I will mention the meteorological chart just completed by Lieutenant T. A. LYONS. In place of the confused and complicated old Maury charts this chart gives us on every square of latitude and longitude, barometric notes, lines of the winds and currents, and everything essential and useful to know, in clear and legible and beautiful outline, so that "he who runs" his vessel "may read" them by the dim light of a cabin lamp.

I mention this as a mere incident to illustrate one of the features of this service, and not to the disparagement of much other valuable work done by that office. It is a simple expression of my estimate of the importance of the duties with which that office is charged, and which it is so efficiently performing for our naval department.

Rear Admiral AMMEN. I have to thank Commander GIBSON for reminding me and the Institute of the very great value of the Hydrographic Office. It only goes to show how extensive and varied the purposes of a Navy are; and I am quite sure that I have taken too much interest in Hydrography to fail for a moment to appreciate that work. The fact that I did not name it in my paper is simply other evidence of the truth that so wide and multiform are the purposes of the Navy that the limits of a single paper such as I had prepared, could not be expected to include all of these important interests and offices of the naval service.

Captain S. R. FRANKLIN. Mr. Chairman if there is nothing more to be said by way of conversation or discussion of the paper just read, I move

that a vote of thanks be extended to Admiral AMMEN for his very able and instructive paper.

The motion was agreed to and the vote of thanks unanimously passed.

Rear Admiral AMMEN. I feel very much obliged to you, gentlemen of the Institute, for your kind appreciation of my paper.

Rear Admiral JOHN RODGERS (the President). It seems to me, gentlemen of the Institute, a fear may well be entertained that the regular men-of-war will not engage with any great earnestness or heart in making surveys. The officer employed in the specific duties of a man-of-war, looks perhaps with impatience at work which, more or less, diverts him from the main objects and purposes of a regular cruiser. You cannot expect a company of soldiers, enlisted for military duty, to make canals, or to construct railroads willingly, however necessary these may be, and however useful to the country.

It seems to me, therefore, that surveys must be assigned to special vessels. I know that when officers of men-of-war have been called on to make charts, they have looked upon it as something outside of their regular line of duty. It often happens that officers of good attainments know little about hydrography; some of them, I fear, care little about it. They naturally prefer to see the surveys and charts made by those who have specially studied hydrography, and who know exactly how these things should be done. I think, therefore, it is important that vessels should be sent abroad charged with the special duty of making charts, and having officers specially detailed for this important part of naval work. The world is full of erroneous charts: we do not want to increase their number. What we need now is something more accurate and more reliable than we find in antiquated charts of half-civilized countries. The time of running surveys is virtually past. What we want, where we have need of new work, is, specific, accurate, and minute surveys.

## PROFESSIONAL NOTES.

These articles not having been read before the Institute are inserted by direction of the Executive Committee.

## Rooms for Recreation and Places of Refuge for the Crews of the Several Squadrons.

### extract from a report to the president of the french republic.

By Vice Admiral A. Pothuau, Minister of Marine, April 1878.

Translated by Duncan Kennedy, Lieut. U. S. N.

In addition to the information given in the report submitted to the President of the Republic upon the state of elementary instruction in the fleet, the Minister of Marine believes it to be a duty to publish the following notice, relating to the results of moral measures taken to establish for the men of the different squadrons rooms for recreation and places of refuge.

The establishing of rooms for recreation and places of refuge dates back to the year 1872; at that time Vice Admiral Pothuau, in charge of the Navy Department, ordered the experiment to be made, and it was not long before the results justified the step and showed the propriety of developing these new institutions as far as possible. An order dated Nov. 26, 1873, officially recognized these institutions at the five naval stations—Cherbourg, Brest, Lorient, Toulon, and Rochefort—and authorized the rules for internal regulation which had been proposed at the station at Toulon. The results have far exceeded the hopes of the most sanguine, and the rooms for recreation in conjunction with the libraries, providing sailors while on shore with wholesome amusements of a moral character, are fully appreciated.

The rooms are large and airy, bright and warm in winter, and are provided with tables and benches. Connected with them are restaurants, tobacco shops and stands for the sale of toilet articles and perfumery desired by sailors. The men smoke and amuse themselves as they please, feeling that it is their own house, while a very slight watching suffices to maintain perfect order. It is the place of meeting for sailors and under officers of all grades, who mingle according to their individual likings.

At present the recreation rooms provide ample amusements of all sorts; noisy and boisterous sports outside in good weather, and inside the rooms themselves. There is an annual appropriation for purchas-

ing and renewing such games and amusements as are most to the taste of sailors. The reports from the different stations are unanimous in proving the advantages of these institutions, which fulfil perfectly the objects for which they were established; to furnish amusement for the men and to draw them away from rum shops, by making their time at the rooms pass agreeably. It is in winter especially that these places are of great benefit by furnishing the sailors with a place in which to spend their liberty in good condition.

During the last five years most interesting details of the working of these rooms and of the additions which they are daily receiving, have been sent to the Minister of Marine. At Cherbourg the sailors frequently meet for games which are followed by the distribution of prizes. An idea none the less happy has been the establishing of shooting matches, which are held every Sunday and holiday. Finally to encourage the men in this sport, every where thoroughly appreciated, special targets have been used in these matches.

Brest gives figures which speak for themselves. During the first quarter of 1874, the admissions to the rooms amounted to twenty-one thousand eight hundred and sixty-two before the retreat* had sounded and to four thousand three hundred and twenty-eight after the retreat, two thousand four hundred and forty-six men who came not being able to find room.

There is no time, as the reports show, when the men are anxious to escape and crowd to the doors at which they are free to go out; for they have now within their reach amusements which restrain them and moderate the longing to rush outside, formerly so irresistible. Frequenting the recreation rooms seems to be becoming more and more a habit with the sailors at Brest, just as at the other ports.

At Lorient it is proved that these rooms for recreation have aided greatly in diminishing the number of the cases of intoxication. Not only are the rooms largely frequented, but it is at the same time noticed that the men, after strolling through the town and the country, return to the navy yard to meet and enjoy themselves while waiting for the time to return to their ships or quarters.

At Rochefort the result is the same.

These rooms, says the report, are great competitors of the rum shops, to the great advantage of our sailors.. Finally this is what is said in the report from Toulon :

* The retreat is the call to return to the Navy Yard, and is sounded when the liberty is up so that the men may know when to return.

" In conjunction with the library the rooms for recreation have enabled many men to shun the unwholesome temptations of the streets; and to those who were accustomed to abandon themselves to this common way of living, it will in time become a thing of the past, remembered as one of the distractions incident to the exigencics of the service."

Thus it is acknowledged everywhere, that the establishing of rooms for recreation is one of the most useful and efficacious means which have been attempted of late years, for entertaining and improving sailors. They seem to understand and appreciate all that has been done for their comfort, and there follows a feeling of gratification which must contribute to the good discipline noticable in them. It may be asserted without fear of contradiction, that these institutions exercise a great and salutary influence on their conduct. Nowhere is there any complaint of the behavior of the sailors in the rooms; good order and discipline are never disturbed. The principal games in vogue and common to all the stations are as follows: rings, cup and ball, billiards, bowls, cards, checkers, dominoes, croquet, chess, skittles, and solitaire. The most popular out-door games are bowls and skittles, while in-doors cards, checkers, dominoes and loto, hold the first place; the warrant officers particularly play billiards a great deal.

## Places of Refuge.

In a different manner, but still in the same general plan, the places of refuge render our sailors great service in allowing them always to find a free lodging for the night, and in removing them from temptations to which they might be exposed, to the great detriment of their health and purse.

It is well known that it is the rule in the navy to keep men busy every day in the week, giving them liberty only from evening till morning; a careful investigation has demonstrated the necessity of keeping up this old custom in the different divisions of the fleet. These places of refuge are for the benefit of the men whose families do not live at the post and who consequently cannot spend their nights at home, that they may enjoy their liberty in rest and quiet amusements.

These places were first established towards the close of 1872, and since then they have been regularly instituted at the five stations except Lorient, where the conditions were such as to offer no facilities for the establishment of such an institution. As the sailors begin to appreciate the resources and benefits of these establishments, they are

everywhere being extended. The places offer certain comforts in accommodations for sleeping and bathing. The policing of the place is confined to a boatswain's-mate. At Toulon, the place of refuge is on board the hulk "Patache," where about fifteen beds are placed at the disposal of the sailors, each of whom as he comes in, receives a mattress and bed clothes; a very well arranged lavatory completes the establishment.

Upon entering, the men give their names, their service numbers, and state if they belong to the station, or to what ship. These different statements are entered in a register provided for the purpose, and kept by the boatswain's-mate in charge. A small locker containing a number of separate compartments corresponding to the number of the disposable beds, is placed for the use of the petty officer in charge, for storing the money, jewels, papers, &c., which may be deposited with him by the men who come to pass the night at the refuge. Printed regulations, setting forth the rules adopted for the interior police of the refuge, are hung up in the rooms; they show the punishment to which any man renders himself liable who disturbs the good order of the place, and how he may subject himself in one way or another, to punishment by the authorities. It is very seldom that the authorities are forced to resort to repressive measures, the reports from the different stations showing on the contrary that everything goes on quietly, and that punishments are almost entirely unknown.

The following table shows the number of men who take advantage of these places to pass the night; these figures bear ample witness to the usefulness of these institutions.

| PORTS. | 1873 | 1874 | 1875 | 1876 | 1877 | Total. |
|---|---|---|---|---|---|---|
| Cherbourg, | 1437 | 1951 | 2851 | 4196 | 2676 | 13111 |
| Brest, | —— | 835 | 1041 | 4153 | 6076 | 12105 |
| Lorient,* | —— | —— | —— | —— | —— | —— |
| Rochefort, | —— | 3108 | 5973 | 6873 | 6586 | 22540 |
| Toulon, | —— | 1252 | 4341 | 5045 | 3468 | 14106 |
| | 1437 | 7146 | 14267 | 20267 | 18806 | 61862 |

A room called the "resting place" is provided for sailors travelling to Paris. It is open, according to the season, from 6 or 7 in the morning till 9 at night. The men find in this place a comfortable shelter, camp beds and covers on which they can sleep, a library and illustrated journals. Here they can make themselves neat and presentable; but

* As there are no *rooms* of refuge at Lorient, measures have been taken to allow the men from the different vessels to sleep on board hulks as far as they can be accommodated. This arrangement is regularly organized and gives results similar to those obtained at other stations.

what is more important is that here they are protected from the solicitations of runners who, under the pretext of carrying their bags and guiding them in the city, steal their money and entice them into grog shops. The boatswain's-mate in charge after having directed the men to the railway stations gives them all necessary instructions about the departure of the trains in different directions and about the public houses which have agreed to take sailors at reasonable rates.

The rooms for recreation and places of refuge have made a real advance in the rude lives of the sailors, who are by these means removed from the isolation and the temptations which to them are very great. These men are under no restraint outside of the service, but the attempt is made by every means possible to keep them at all times willingly under the regulations of discipline and duty. Experience has already shown them how great are the advantages to them of such institutions, for which they are indebted to the Navy Department.

# NOTE OF THE MANUFACTURE OF NITRO-GLYCERINE AT VONGES.

Professor Charles E. Munroe, U. S. N. A.

On page fifteen, of the present volume, I have described the process for the manufacture of nitro-glycerine, in use at Vonges and there I stated that as the factory was not in operation, I could only see the apparatus used, and hence there was a possibility that I had omitted some essential points in my description.

Since presenting this paper I have received a copy of the second volume of Upmann & Meyer's Traite de la Poudre, translated from the German, and considerably augmented by E. Désortauix, which has just been published in Paris. This contains the first description of the process, with the exception of mine, which has been published, and it confirms my description, with the following additions:

The mixing of the glycerine and sulphuric acids is effected in the mixing trough, shown in Fig. 8, by allowing thirteen kilos. of glycerine to run slowly into the trough in which 41.6 kilos. of sulphuric acid has been placed. The stirring is continued for an hour or an hour and a half, according to the season.

The lever, which is represented in Fig. 9, attached to the cover of one of the cells in the battery, is counterpoised so that a slight increase in pressure will lift the cover out of the trough and unseal it.

The temperature rises in the converting cell during the first quarter of an hour after the mixing is effected, to a maximum of from 27° C. in November to 48° in August, varying with the season.

The product is drawn off by leaden siphons, the acid being drawn first into glass carboys and then the nitro-glycerine into earthen vessels. In the washing room the nitro-glycerine is thrown into large, glazed cylinders, containing water; the nitro-glycerine sinks to the bottom and is drawn off by a stop-cock. The washing is completed in large agitators, similar to those shown in Fig. 8, fifty-five kilos. of nitro-glycerine being mixed with three times its volume of water heated up to 30° C. It is washed thus from ten to eighteen times, and to the last two portions of water one hundred grms. of bicarbonate of soda are added. The opaque hydrated nitro-glycerine is now dried by filtering it through layers of sponge placed in a tin plate cylinder, the bot-

tom of which is pierced with holes. The nitro-glycerine is squeezed out by means of a perforated wooden plunger, while the water remains behind in the sponge. This operation is repeated until the nitro-glycerine is perfectly clear.

# NAVAL INSTITUTE PRIZE ESSAY, 1880.

A Prize of one hundred dollars and a gold medal of the value of fifty dollars is offered by the Naval Institute for the best essay presented subject to the following rules.

1. Competition for the Prize is open to all persons eligible to membership.

2. Each competitor to send his essay in a sealed envelope to the Secretary on or before the first of January, 1880. The name of the writer shall not be given in this envelope, but instead thereof a motto. Accompanying the essay a separate sealed envelope will be sent to the Secretary, with the motto on the outside and the writer's name and motto on the inside. This envelope is not to be opened until after the decision of the Judges.

3. The Judges to be three gentlemen of eminent professional attainments to be selected by the Executive Committee.

4. The successful essay to be published in the proceedings of the Institute, and the essays of other competitors to be published also, at the discretion of the Executive Committee, with the consent of the writers.

5. The successful competitor shall be made a Life member of the Institute.

6. The subject for the Prize Essay is "THE NAVAL POLICY OF THE UNITED STATES."

7. The Essay is limited to forty-eight printed pages of the proceedings of the Institute.

Art. IV. Sec. 2 of the Constitution provides that "All officers of the Navy and Marine Corps, and all civil officers attached to the Naval service shall be entitled to become members.

The money value of the medal may be given to the successful competitor if he so elect.

JOHN C. SOLEY, Secretary.

Naval Academy, Annapolis, March 1879.

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# CONSTITUTION.

## TITLE.

Article I. The Organization shall be known as the United States Naval Institute.

## OBJECT.

Art. II. Its object shall be the advancement of professional and scientific knowledge in the Navy.

## ORGANIZATION AND OFFICERS.

Art. III. Sec. 1. The officers and permanent committees of the Society shall include:—

A President.
Vice Presidents.
A Secretary.
A Corresponding Secretary. } Executive Committee.
A Treasurer.
A Committee on Publications.
Corresponding Secretaries for Stations.

Sec. 2. Special Committees may at any time be appointed by a majority vote of the society to consider questions not properly under the cognizance of the Standing Committees.

Sec. 3. There shall be a Vice President and Corresponding Secretary in each squadron and at each shore station who shall be chosen to hold office for one year by the members of the Society on that station.

## MEMBERSHIP.

Art. IV. Sec. 1. The Institute shall consist of members, life members, honorary members and associates.

Sec. 2. All officers of the Navy, Marine Corps, and all civil officers attached to the Naval service shall be entitled to become members without ballot, on payment of dues to the Treasurer or to the Corresponding Secretary on the station.

Sec. 3. All those who are entitled to become members, may become life members, on payment of thirty dollars. As a reward for extraordinary services to the Institute, or as a mark of honor, the Institute may create life members without payment of dues: nominations for life members must be made by the Executive Committee and a majority vote of members shall be required to elect the candidate. The Prize Essayist of each year shall be a life member without payment of dues.

SEC. 4. Honorary members shall be selected from distinguished Naval and Military officers and from eminent men of learning in civil life; provided that the number of such members shall in no case exceed thirty.

SEC. 5. Associates shall be chosen from persons connected with the Naval and Military professions and from persons in civil life who may be interested in the objects that it is the design of the Institute to advance.

SEC. 6. Honorary members and Associates shall be elected as follows: nominations shall be made in writing to the Executive Committee and such nominations, with the name of the member making them, shall be entered on the minutes of the Committee. At the succeeding meeting of the Institute, the Committee shall report. If their report be favorable, a majority of the members present shall decide the election: but if unfavorable, a two-thirds vote shall be required to elect the candidate. Two members of the Executive Committee shall constitute a quorum for carrying out the requirements of this section.

SEC. 7. The annual assessment for a member shall be three dollars and for an associate one dollar, payable upon joining the Institute and on the first day of each succeeding January.

SEC. 8. Membership shall be forfeited in cases when the recommendation of the Executive Committee, supported by a two thirds vote of the society shall so determine, and members two years in arrears shall be dropped. Those who have been dropped from the list of members for being two years in arrears can only regain their membership by paying up their arrears.

## NOMINATIONS AND ELECTIONS.

ART. V. SEC. 1. There shall be a meeting of the society on the second Thursday, in January of each year at which all officers shall be chosen, except those provided for in Art. III. Sec. 3.

SEC. 2. Members not in attendance may vote by proxy at such elections as well as upon questions relating to the Constitution and By-Laws, but vote by proxy will only be allowed in the two cases herein specified. Life members have full rights with members to vote on any question. Honorary members and associates will not be allowed to vote on any question.

SEC. 3. A majority of votes recorded shall determine choice.

SEC. 4. Members elected to the position of officers of the Society will assume their duties as soon as notified.

SEC. 5. Vacancies may be temporarily filled by the Executive Committee but regular nominations and elections shall follow as soon as practicable.

SEC. 6. All voting for officers shall be by ballot in session of the Society.

## DUTIES OF OFFICERS.

Art. VI. Sec. 1. The President or, in his absence, the Vice President, or, in the absence of both, a member of the Executive Committee will preside in Executive session.

Sec. 2. The transaction of all financial executive or administrative business, in which latter shall be included censorship of papers offered for presentation to the Society, shall be in the hands of the Executive Committee. The Committee will determine for itself its routine of business and form of record.

Sec. 3. The Secretary shall keep a register of the members, a copy of the Constitution and By-laws in which he shall note all changes, a journal of the proceedings of the Society, a separate record of the proceedings of the Executive Committee, and a file book in which the reports of Committees shall be entered. These books shall be at all times in readiness for inspection. Papers offered by members unable to be present, if accepted by the Executive Committee, shall be read by the Secretary. He shall give due notice of all meetings of the Society, and shall have control of the stenographer and copyists employed to prepare records of the proceedings.

Sec. 4. The Corresponding Secretary shall attend to all correspondence and keep a record thereof.

Sec. 5. The Treasurer, under the direction of the Executive Committee, shall be the disbursing officer. He shall keep a receipt and expenditure book and an account current with each member. He will submit his books for examination whenever asked for.

Sec. 6. The Committee on Publication shall have charge of the printing and publication of all papers and proceedings of the Society.

Sec. 7. Corresponding Secretaries of Stations shall keep the Institute, through its Corresponding Secretary, advised of new members and of all matters of interest and shall attend to the collection and transmission to the Treasurer of the dues of members.

## MEETINGS.

Art. VII. Sec. 1. There shall be a meeting of the society on the second Thursday of each month for the discussion of professional and scientific subjects.

Sec. 2. Special meetings may be called by the Secretary at the request of one or more of the general officers or of standing or special Committees.

Sec. 3. A stenographer shall be employed to keep the record of all proceedings of regular meetings.

Sec. 4. Annually, or as much oftener as the Executive Committee may decide, a record of papers read before the Society and the discussions growing out of them shall be published in pamphlet form. Papers on intricate technical subjects may

be published as a part of the proceedings of the Society without being publicly read, if in the opinion of the Executive Committee, the subject to which they relate be not of a character to be appreciated on merely casual investigation.

## PAPERS AND PROCEEDINGS.

Art. VIII. Sec. 1. The papers and proceedings of the Institute shall constitute assets, and be so borne on the books of the Treasurer and accounted for.

Sec. 2. One copy of the proceedings, when published, shall be furnished to each member, life member, honorary member, and associate member, the Library of the Naval Academy, corresponding societies, Congressional Library, Boston Public Library, Library of Harvard University, and Naval Library at Mare Island.

Sec. 3. Back numbers of proceedings shall be furnished to members at a charge which shall be fixed by the Executive Committee. The proceedings may be furnished to non members at a cost 10 per cent. higher than that at which they are furnished to members.

Sec. 4. No copies shall be furnished to members who are one year in arrear.

## AMENDMENTS.

Art. IX. No addition nor amendment to the Constitution and By-Laws shall be made without the assent of two thirds of the members voting. Notice of proposed changes or additions shall be given by the Secretary at least one month before action is taken upon them.

# BY-LAWS.

ARTICLE I. The rules of the United State House of Representatives shall, in so far as applicable, govern the parliamentary proceedings of the Society.

ART. II. 1. At both regular and stated meetings the routine of business shall be as follows :

2. At executive meetings, the President, or in his absence, the Vice-President, or, in the absence of both, a member of the Executive Committee will call the meeting to order and occupy the chair during the session; in the absence of these, the Society will appoint a chairman.

3. At meetings for presentation of papers and discussion, the Society will be called to order as above provided, and a chairman will be appointed by the presiding officer, reference being had to the subject about to be discussed, and an expert in the speciality to which it relates selected.

4. At regular meetings, after the presentation of the paper of the evening, or on the termination of the arguments made by members appointed to, or voluntarily appearing to enter into formal discussion, the chairman will make such review of the paper as he may deem proper. Informal discussion will then be in order, each speaker being allowed not exceeding ten minutes in the aggregate, unless by special permission of the Society. The author of the paper will in conclusion be allowed such time in making, a résumé of the discussion as he may deem necessary. The discussion ended, the Chairman will close the proceedings with such remarks as he may be pleased to offer.

5. At the close of the concluding remarks of the Chairman, the Society will go into Executive Session, as hereinbefore provided, for the transaction of business, as follows :

1. Stated business, if there shall be any to be considered.
2. Unfinished business taken up.
3. Reports of Officers or Committees.
4. Applications for membership reported.
5. Correspondence read.
6. Miscellaneous business transacted.
7. New business introduced.
8. Adjournment.

# CONTENTS.

# THE RECORD

OF THE

# UNITED STATES NAVAL INSTITUTE.

## NAVY DEPARTMENT, WASHINGTON,

FEBRUARY 27, 1879.

Rear-Admiral THORNTON A. JENKINS (Vice President), in the Chair.

## NAVAL AFFAIRS.

BY LIEUTENANT FREDERICK COLLINS, U. S. NAVY.

MR. PRESIDENT AND GENTLEMEN :—

Having accepted your kind invitation to read a paper before the Institute, I had already progressed well towards the completion of an essay before I knew that the very distinguished officer who read the last paper* had selected a subject almost identical with that on which I proposed to address you. On listening to his very able paper, at the last meeting, I was not a little gratified to find his views according generally with those set forth in my own paper, then already nearly prepared. His very clear and thorough exposition of the points discussed would appear to render superfluons any further treatment from me, yet I venture to lay before you what I had prepared, hoping that as the subjects treated are of wide scope and vital importancee, another discussion of them from a somewhat different standpoint, may not prove uninteresting as cumulative evidence of the tendency of thought in the service at the present time.

In the brief space of a single paper, so broad a subject as that to which I invite your attention this evening, can be considered in a few of its phases only, and they merely in outline. In what follows I propose to discuss briefly the necessity for maintaining a powerful navy; the condition of our present establishment; and to propose such changes in certain particulars as are, in my opinion, necessary to enable

* "The purposes of a Navy, and the best means of rendering it efficient," by Rear-Admiral Ammen.

it to perform its legitimate functions with efficiency, economy, and credit to the country, both in peace and war.

It may be considered idle for me to enter into argument to show that the prosperity and safety, as well as the prestige and dignity, of our country demand the maintenance of a powerful navy, for the arguments have often been presented with much more force and cogency than lie within my power. But, whether it be that our civil polity is not prolific in statesmen of broad views, or that the principles of political economy have with us no other outgrowth than partisan parsimony, or whether it be for some other reason less obvious to the average mind, it is certainly true that argument and the voice of history alike have thus far appealed to deaf ears. The facts therefore cannot be too often repeated and insisted upon.

"The Navy," says the Secretary in his report for 1871, "is our only means of direct protection to our citizens abroad, or for the enforcement of any foreign policy; and while we may have some reason to hope that in our own generation we may see the beginning of the end of warlike strife among the more enlightened and free of civilized nations, yet we cannot expect that the world will be wholly civilized in our day, nor that freedom will come to it without contention. Barbarism will still respect nothing but power, and barbaric civilization repels alike interference, association and instruction. Even in civilized communities, ambitious, selfish and turbulent passions will sway the actions of men, and arbitrary power will not yet resign, without a struggle, its hold on the organization of civilized society. Not only on the shores and among the islands of our own continent, but in every sea-port of civilized Europe; in Asia, from the shores of the Bosphorus to the head of navigation of unnamed rivers on the confines of the Chinese Empire; in Japan; in the islands and semi continents of the East, and among the groups of the Pacific and the Southern Oceans, our citizens claim and need protection. In every quarter of the known world they are found occupying every field which enterprise dares invade, or which energy avails to conquer; and everywhere, outside of our own limits, wherever they enter, they carry with them affirmative, and sometimes aggressive, ideas of freedom and progress, antagonistic alike to the traditions, customs and habits of the people, and the ideas and practices of local governments. Such is the result of our progressive civilization upon the enterprising and affirmative spirit of our people. Its effect is apparent in every land that they penetrate; and we cannot afford, either as a government or as a people, to neglect wholly our re-

sponsibilities as a representative nation, nor our national obligations to our citizens who, wherever they are, claim the countenance of the government and the protection of its flag."

In all nations commercial supremacy and naval power have gone hand in hand. That the former should precede and the latter follow is true; but we have once made the fatal mistake in this country of permitting our commerce to develop with no commensurate addition to our naval strength, and, should occasion offer, it is to be feared that we will do so again. Moreover a recognition of their intimate relations should impel any nation discovering its commerce on the wane to redoubled efforts to maintain an efficient navy as one of the most important aids to its resuscitation. In times of commercial prosperity good seamen are abundant, and vessels more or less fitted to serve a temporary purpose in the navy may be had when wanted. But when commerce has long been on the decline, neither the seamen nor the ships are forthcoming on demand. How much the more necessary then to exercise the most solicitous care, at such a time, to maintain a proper naval establishment, ships, officers and men.

If we can go to market when we like and buy as occasion demands, we may, perhaps, look upon an empty larder with some degree of complacency. But when the market is not at hand we should stock our cellars lest the unexpected arrival of a guest put us to shame. War, happily for us, has not been a frequent guest, but it is his habit to call on short notice and to stay after his welcome is well worn out. It therefore seems the part of prudence to maintain a reasonable state of preparation.

Diminished revenues may imperatively demand a diminution of expenditures, but in reducing our military establishments we should at least preserve always the elastic nucleus capable of immediate expansion when times demand. In starting upon the work of reduction both in the army and navy at the close of the civil war this principle seems to have governed. But of late it appears in danger of being forgotten.

There is a legend afloat in the service (I dare say you have all heard it) of a certain First Lieutenant of the olden time, who, considering that the bean broth made for the ship's company was too thick, ordered that the trouble should be corrected by putting in fewer beans. This order obeyed, it resulted that the broth was too thin, whereupon less water was ordered. Thus, beans and water were alternately abstracted till nothing was left. So with the army and navy, they never seem to be exactly right, but, thick or thin, the remedy is always subtraction—

never by any chance, addition. It is just now complained that the navy is too thick with officers. This may or may not be true, but, as there is not enough of it as it stands to satisfy the needs of the country, the proper remedy would seem to be to dilute it with a few men.

There are certain cases in which the statement of an isolated fact, however incontrovertible the fact in itself may be, inevitably leads to erroneous conceptions of the subject to which it relates. A boy in school who reported himelf as standing next the head of his class was warmly congratulated; but, when it appeared that there were only two in the class, his brilliancy was questioned although his veracity could not be doubted. So when the statement is made that there is one officer to every three men in our navy, the impression naturally is that the number of officers is excessive and should be reduced. But when we learn that there is in the navy only the six thousand six hundred and sixty-sixth part of a man for each inhabitant of the country, it appears rather that the number of men is ridiculously small and should be increased.

In appealing to the past to show the necessity for a navy to protect our commerce, we need not go beyond the history of our own country, nor to the record of events more distant than those within the vivid recollection of all here present. During the half century succeeding our last war with Great Britain our commerce developed with unexampled rapidity. In 1860, the carrying trade of the world was largely in our hands and seemed likely to remain in them. Relying, however, upon a blind belief in the "manifest destiny of the Republic," as the phrase was, no adequate navy had been created for its protection. In the following year, like a thunderbolt from a clear sky, the blow fell from a most unexpected quarter and our flag became a stranger to the seas.

To my mind there is no doubt that, had an adequate naval force been at the disposal of the government at the outbreak of the civil war, the ports of the states seceding would have been seized before they could have been put in a posture for defence. Not a blockade runner could have entered; not a rover could have escaped to prey upon our commerce; those fitted out elsewhere would have been cut short in their careers of destruction; and, in a word, the whole train of causes leading to the extinction of our foreign carrying trade would have been nipped in the bud. How much better for all concerned on both sides would not this prompt settlement have been, than the long years of strife and blood now a part of our history?

Protracted and exhausting internal strife is quite as fatal to the commerce of a country as foreign aggression. To put a stop to either in the shortest possible time, and with the least possible loss, no means at the disposal of a country situated as this one is, can be more efficient than a powerful navy.

But if the teachings of the past are insufficient let us glance at the possibilities of the future. Suppose our commerce to start now upon the career of prosperity that the near future seems to promise. Suppose that it develops until it begins to threaten to control the carrying trade of the world. Suppose, all other means failing to arrest our progress, the hands in which the carrying trade now rests—hands at once so dependent upon it and so capable of defending it—decide to appeal to the arbitrament of war. Suppose, finally, the relative naval strength of the two countries to remain as it now is. What would be the result? I venture nothing in saying that, within one month from the declaration of war, our commerce, foreign and coastwise, would be annihilated: our principal seaports, even if we succeeded in defending them from capture would be hermetically sealed, while our coasts would be ravaged from the St. Croix to the Rio Grande. This, of course, could not go on forever. We should devise means to drive the hostile fleets from our coasts. But this would take time. Meanwhile the mischief would have been done, and property destroyed in thirty days of sufficient value to cover the expenses of an efficient naval establisment for thirty years.

We have never yet had a war with a naval power in a position to give us its undivided attention. When we do, if the unlucky day finds us as ill provided as we we now are, our countrymen will look with astonishment upon the methods of annoyance that modern means of warfare will place within the reach of an alert and aggressive foe.

But if it is neither to be supposed that a war of two great sections will ever again desolate our country, nor that we are liable to attacks from without, the experience of the past few years should teach us that domestic violence, in the form of serious riots, is to be anticipated from within. Eras of discontent among certain classes of our population are sure to come. We live in an age of sudden and radical changes. New discoveries are constantly demanding a more or less extensive readjustment of our social, commercial and industrial relations, and while such readjustments are in progress, large bodies of persons are sure to suffer. At such times it is not unnatural that the persons thus affected should look upon their changed condition (though

brought about by the operation of natural laws as immutable as the principles governing the material universe) as forced upon them by conspiracy on the part of those more fortunately situated than themselves. As far as our native citizens are concerned there is nothing to fear, but we have a large heterogeneous foreign population comprising many elements of a most dangerous character. Among us but not of us, they are the scum thrown off by the ever-boiling political cauldron of Europe, as from time to time it becomes too hot to hold them. They are neither of our race nor our ways of thinking. Unaccustomed to the methods by which our citizens, under a free government, express their will with the ballot, and unmindful of the horrors of anarchy—the bare possibility of which is worse than almost any evil that can befall a people under even the worst form of government—they look upon a resort to violence as the only cure for all the ills of their condition, real or imaginary. Congregated chiefly in the populous cities of our seaboard, and standing as they do ever ready to fan the spark of discontent into the flame of violence, these people are a perpetual menace to the stability of our social and political fabric.

I do not share with Lord Macaulay his apprehensions that in some season of adversity our people will do things that will prevent prosperity from returning; that there will be spoliation increasing the distress, and distress inciting to fresh spoliation, until either civilization or liberty must perish: until either some Cæsar or Napoleon will seize the reins of government with a strong hand, or our republic will be as fearfully laid waste by barbarians from within as was the Roman Empire from without. I do not fear, I say any such fearful culmination as that, for I have faith in the "saving common sense" of our citizens to teach them that the true interests, of every person, rich or poor, not a professional pirate upon society, are best served by the maintenance of law and order. But I do fear that a lack of preparation to crush such demonstrations at their inception may lead to their more frequent occurrence and enable them to assume serious proportions, with deplorable consequences, when otherwise they would have proved of little moment.

As these scenes of violence are likely to have their commencement in our seaboard cities, the Navy, evidently, is a most efficient instrument for their suppression. Our seamen, as well as the marines, are now so drilled as to operate on shore with all the facility of soldiers; and the man-of-war, ready to proceed at once to any point accessible by water,

and carrying with her everything necessary to make her a base of supplies for her forces, realizes in the highest possible degree that mobility necessary where widely separated points are to be protected by a comparatively small force.

The necessity for a Navy of some sort, however, while by no means unquestioned, is so generally admitted that the main interest for us centers rather upon the second point proposed for discussion ; the present condition of our naval establishment.

We naturally commence a consideration of this question by an inventory of our possessions in the naval line. The list, unfortunately, is not long ; still, we have some things that are really valuable and which were we without, the creation of a navy would be truly a formidable task. What then have we? First, an organization in running order, which, (although it could, in the opinion of many, be changed greatly for the better) has proved itself competent to administer with a certain degree of efficiency the affairs of a navy as large as we may wish to create. Second, a corps of trained officers comprising in its various branches, it is to be supposed, all the talent necessary to create, organize and maintain an efficient naval establishment; and already sufficiently large to officer a respectable navy whenever Congress shall see fit to provide proper ships and seamen to man them. Third, the finest educational establishment of the kind in the world, capable of turning out as many graduates as the casualties of the service in any ordinary times may require. Fourth, the nucleus of a training system that seems likely to give the service a superior class of American seamen, devoted to the flag and trained to the service, to supersede the motley crowd (not long since manning many of our national vessels) whose speech was a confusion of tongues, and to whom the Stars and Stripes or the cross of St. George were alike objects of indifference, symbolizing nothing higher than pay, nothing holier than rations. Fifth, a number of well situated yards where the facilities for the construction of any type of vessel and ordnance we may require already exist, or may readily be supplied. Sixth and last, to sum up briefly, a fleet of some sixty cruisers of antiquated type, mostly in various stages of dilapidation, poorly armed and of insignificant speed, with some two dozen iron-clads, having neither the armor to make them impregnable nor the ordnance to make them formidable.

This last is almost calculated to provoke a smile, yet we are talking seriously of the navy of a nation of forty millions of people, proud and progressive, the sails of whose ships have in times past "whitened

every sea," and who look confidently forward to the day in the near future, when they will do so again. Such a state of affairs is certainly anomalous; how then is this decline of our naval power till it approximates the vanishing point to be accounted for? Many causes, some of large influence, others of small, some of direct and immediate influence, others of indirect and remote, have of course contributed to bring it about. But, in my opinion, it may be traced to three principal causes of which I mention as the first, although it may not be the chief, the results of our experience in the late civil war.

The history of the part taken by the navy in that struggle, is certainly a glorious one. The results achieved were amazing to the world and most honorable to all connected in any way with producing them. But the circumstances were peculiar and our exultation over our success should not blind us to the facts, nor lead us into false conclusions. Our navy in 1861, though relatively of much greater strength than now, was utterly inadequate to the gigantic task set before it, yet we soon improvised an establishment of enormous proportions that proved wonderfully successful in accomplishing the difficult work that fell to its lot. Seeing these successes, and not qualified to judge of the circumstances, the public not unnaturally has become possessed of the idea that it will always be possible to improvise a navy when war threatens, and, consequently, that in times of peace hardly anything more is necessary than that a few educated officers should keep alive the germs of naval knowledge, much as the monks did that of letters during the middle ages.

This idea in the public mind is, I say, not unnatural, but those qualified to judge, know it to be utterly fallacious, and it is our duty to warn the country of the danger into which such ideas will lead it; to teach our fellow citizens to draw correct lessons for their guidance in the future, rather than to allow themselves to be lulled into false security by basking in the light reflected from the great achievements of the past.

The circumstances of our last war were, as I said, peculiar, and not likely to recur. Our next war will, in all likelihood, be with some nation possessing a powerful naval force. Suppose, now, the states lately seceding had possessed such a force at the outset, while the general government was as poorly provided as at present. How quickly would the tables have been turned. How infallibly would our principal seaports have fallen at once into their hands; of what avail against their powerful cruisers with trained officers and disciplined crews,

would have been our gun-boats, hastily improvised from the most incongruous and unsuitable material, manned, and in many cases officered, by fresh recruits entirely destitute of naval training and experience? they would have been swept from the sea, if indeed our ports had not been siezed before time was given us to fit out even such travesties on men-of-war. The tables, I repeat, would have been turned; northern ports would have been closed while southern ones would have remained open to receive supplies from those so eager to furnish them, and the flag of the Confederacy with the prestige of such success would have been recognized in Europe ere the nation had half recovered from the stunning blows thus showered upon its defenceless head.

Such would have been our experience then: such it will be in the future if we allow ourselves to be drawn into war as ill prepared as we now are. The experience of the last ten years shows that wars in these days are short and decisive. The strongest and best prepared nation advances like an avalanche and overwhelms its foe. We may be protected by our situation from being overwhelmed, but not from the infliction of loss, annoyance, and suffering, of which in advance we can form but little conception.

Our best means of defence against foreign aggression is, of course, a navy, and the idea that one can be improvised under the spur of necessity is at once foolish and fatal. Trained officers and men will not spring up at our call as clansmen at the whistle of Rhoderick Dhu; neither can ships suitable for naval purposes be built in a hurry, nor patched up out of those taken from the merchant marine.

The second great reason for allowing our naval power to decline, is, I believe, to be found in the general belief, towards which our people have been drifting, that all questions relating to the defence of our coasts and harbors are to be settled in the main by the torpedo. For my own part, I dissent entirely from this belief. I yield to none in honoring the officers of our service who have with such genius developed the capabilities of this terrible instrument of destruction; nor indeed, I may say, do I yield to any in a most wholesome respect for the torpedo itself. But to assume that, unaided, it can protect us against aggressions from an enemy possessing a powerful fleet, is rating its powers too high.

Whether in the form of the submarine mine, planted in narrow channels, and arranged to be exploded by electricity when the ships of the enemy are in position to receive the full benefit of its terrific power, or as a movable weapon carried by swift vessels, it must certainly form an

important element in our scheme of defence. To whatever state of perfection it may have been brought for use under the former conditions however, much certainly remains to be desired in the latter, and I do not think that naval men have ever anticipated any possible development of it beyond that of a very useful auxiliary to a fleet combining all the other recognized elements of strength, offensive and defensive. The conditions of its use otherwise than as a stationary mine, are such as to involve a great amount of uncertainty in its manipulation, or to admit a correspondingly simple and certain defence, and I do not think we would be justified in placing too much reliance upon its powers.

We have an enormous extent of coast line, along which much valuable property lies within the range of ordnance now afloat, or the easy reach of the enemy in a sudden raid, without the necessity of his taking his ships into any port at all. I doubt, the possibility of our protecting the entrances of Penobscot Bay, Buzzard's Bay, Long Island Sound, Delaware or Chesapeake Bays by torpedoes alone, either fixed or movable. And what damage and annoyance would not be inflicted upon us by an alert and aggressive enemy, *en rendezvous* in either place?

Our coastwise commerce would not last long with an enemy cruising upon our coasts, and torpedoes alone can neither prevent that, nor his covering with a fleet the approaches to New York or Boston, on the breaking out of hostilities, and making a prize of every vessel bound in or out. To protect ourselves from such aggressions as these, we must have at hand the means to drive an enemy entirely from the vicinity of our coasts. The most ready and economical means to effect that object will be considered farther on in this paper.

The third great cause for the apathy with which our people have viewed the decay of our naval power is, I think, to be found in the disagreement among naval officers themselves, as to what should be done to preserve it. If our leading officers had been in accord as to what was wanted, and had worked together to obtain it, it is by no means certain that the appropriations would not have been forthcoming. If the congressman, honestly anxious to learn the wants of the country in the way of a navy, gets from two officers ideas diametrically opposed, and from a third no definite ideas at all, but advice to "lay on our oars", his only escape from the horns of the dilemma would appear to be to accept the latter advice.

Disagreement, however, under the circumstances has been natural, if

not inevitable. All sciences, not mathematically exact, pass through their phases of doubt, disagreement and discussion, followed by periods when all are in agreement, except perhaps the few restless spirits who thrive only on a diet of doubts, and who, however little appreciated by their contemporaries, often appear to posterity to have been the leaven of the lump. Through such a revolutionary period the science of war, perhaps the least exact of all, has been passing for twenty years. Guns have grown until our XV inch, once a giant, has become a pigmy; armor has increased in thickness beyond the wildest conceptions of the last generation; small arms have improved until they are as superior to the old musket as that to the cross-bow; explosives of such terrific power as to make gunpowder quite contemptible have sprung into existence; while the revival of the ram and the introduction of the torpedo in its multifarious forms have entirely upset our traditional notions of naval warfare.

Change thus succeeding change with bewildering rapidity, all who have sought to keep up in any degree with the times have been constantly called upon to absorb fresh ideas before the last had been assimilated. Doubt and disagreement have naturally followed. At the present time signs are not wanting that the era of discussion is setting in, and I am of the opinion that an interchange of ideas will now show an approximate unanimity on leading principles that is to be hailed as the first sign that the star of our navy has passed its lower culmination, and is soon to be again in the ascendant. I am not prepared to say that we have not done well in thus far watching the development of events and getting the benefit of the experience of other powers without cost to ourselves, but it will not do for us to allow ourselves to become entirely extinct as a naval power while waiting for the crucial test of battle to decide points at issue. In the next naval war we ourselves may be one of the interested parties, and however faulty some may think the navies of Europe, few will contend that they are not immeasurably superior to none at all.

While we have been "hove-to" watching the progress of affairs, other nations have worked steadily along, until, what with all that they have gained to windward and all that we have lost to leeward, we are in danger of being left quite "hull down." I submit that it is time for us to "fill away"; to draw what conclusions we may from the experience of others, and set seriously to work to build up a navy suited to the times and the peculiar requirements of our situation, one of such strength and character as to prevent other nations from feeling that they can

assail us with impunity, and that will, should occasion arise, enable us to give a good account of ourselves, as we have done in the past whenever called upon.

The task of building up such a navy will, of course, be a huge one and one involving great expense. At this, however, we should not complain but look upon the money spent as an investment yielding good returns, if for no other reason than that by preparing for war we diminish the probability of its occurrence.

In what I shall have to propose this evening for the improvement of the *materiel* of the navy, (and I shall obtrude none of my opinions touching *personnel*) I lay no claim to novelty or originality. The gist of the scheme was given in a paper of great force and perspicuity, read before the Institute by Commodore Parker in 1874, and it represents, I am inclined to think, in a general way, the views of most of our officers at the present time.

In inquiring as to the means best suited to accomplish the legitimate functions of a naval establishment in the most efficient and economical manner, at the present time, we find that modern means and methods of warfare point to the expediency of a radical departure from traditional systems.

In former times one general type of ships sufficed to fulfil all the purposes for which a naval force could be employed. The "wooden walls" of a country formed a serried rampart against the invading foe, or, scattered abroad over the seas in offensive warfare, sought him out wherever he might be found. But the appliances of naval warfare have so changed of late that a navy containing but one type of vessel, whatever that type might be, would be neither efficient nor economical. Our coasts may be best defended by ships radically different in construction from those adapted to cruising abroad to protect our commerce from depredation and our citizens from outrage. For the latter purposes and to cut up an enemy's commerce in time of war a fleet of swift and heavily armed cruisers is required. For harbor and coast defence our main reliance, so far as the navy is concerned should be upon floating batteries, torpedo boats and rams.

Let us consider first, what we need as a fleet of cruisers.

In these our chief aims should be speed, and handiness with great power and range of armament. In these three qualities we should allow our ships to be surpassed by none. These three qualities are paramount; for with the ships possessing them in a superior degree will go the day in the time of trial. Second to those come the capability

of keeping the sea and making fair time under sail, and as large a coal capacity as can be secured without a sacrifice of the other qualities named. To these five qualities all else should give way. Whatever else of good is attainable should of course be sought and secured, but only so far as may be possible without prejudice to the others.

As for the type of ships which shall unite these desiderata, two of them at least, speed and handiness, are incompatible with any great weight of armor, and I believe that the officers of our navy are pretty well agreed that, as far as we may judge from what has been done on the other side of the water, the contest so long waged between guns and armor has resulted, so far as cruising ships are concerned, entirely in favor of the guns. Or, if that point be not conceded by the partisans of armor, they must at least acknowledge that the armored Achilles presents a very vulnerable heel to the ram, and therefore to the torpedo. If then the armored ship be hardly less vulnerable than her more agile unencumbered foe, it appears to me that in a pitched battle the advantage is quite as likely to be with the latter as with the former. Indeed, I believe that it only remains for the first fleet action to show that, what with their unhandiness and their tremendous momentum, even at low speeds, the armored ships will prove, on the least appearance of confusion in the line of battle, quite as dangerous to friend as to foe.

For our cruisers, then, I would abandon entirely the idea of armor. In discussing the special type to be adopted there is room for great range of opinion, and, of course, none would be decided upon except after the most careful study and deliberation by a board of competent officers who would call to their aid the best talent in the several specialties going to make up an efficient man-of-war that the country affords. The navies of foreign countries, especially those of England and France, offer many examples each with special features worthy of consideration. For myself, though lacking the special knowledge of naval architecture that would enable me to judge of all details, I am very favorably impressed with the general plan of the cruiser proposed by Lieut. J. C. Soley in his valuable paper read before the Institute a few months since. I am of the opinion that vessels of that type with high speed, and rifled guns of great range, would be most formidable engines of war, and economical both as to first cost and current expense of maintenance in commission. I would however venture to suggest a few trifling modifications in the particular plan referred to. In the first place I doubt whether the sail-power of the proposed cruiser is sufficient to

fulfil the purposes set forth by her projector, and I would be in favor of increasing it: bearing in mind, of course, the desirability of avoiding excessive top-hamper. Secondly, I think the point against projecting bows, made by Admiral Porter in his article on Our Navy, in the first number of the "United Service," well taken. Especially in so light a ship as the one proposed would it prove a serious weakness, and I would substitute for it either a straight stem or one formed on the arc of a circle of large radius. Either of these would be much stronger than the "swan breast," and sufficiently effective in ramming. In this connection I would say that I entirely agree with Commodore Parker in thinking that the idea of using a gun-bearing ship either as a ram or a torpedo vessel should be held entirely in the back ground. The energies of an officer commanding such a ship, on going into action should be concentrated upon injuring the enemy with his guns, and his thoughts should revert to the ram only when his guns are disabled or when so incontestably fair an opportunity presents itself as to leave no possible room for doubt in the choice of weapons. Guns, Rams and Torpedoes are each excellent in their way; each indispensable to our naval establishment: but they should not be too much mixed aboard any one vessel.

If we should decide upon the unarmored, composite vessel, sheathed in wood, as the proper type for our cruising navy, the next step would be to consider what classes we should require and how many of each class. Here is scope for the widest differences of opinion. For my own part I would be governed as to class by the general principle of building for the present no ships incapable of carrying a good battery of the heaviest rifled guns, with a view to securing as quickly as possible a fair number of powerful ships, sufficiently alike in size, speed and armament to form a homogeneous fleet. One such ship will add more to our real fighting power, and especially to our power of acting on the offensive, than half a dozen gun boats. Small ships are useful for many purposes both in peace and war; but they can never form any part of the body of a formidable fleet. We have quite a number of them already, or, at all events, ships that will serve very well every purpose to which a small vessel can be put, can easily be procured at any time. But, as has been said, ships fit to fulfil the purposes of a powerful man-of-war can neither be built in a hurry nor converted from vessels taken from the merchant marine.

In a general way I would place the lowest limit of any vessel that we ought now to build at three thousand tons displacement; and,

perhaps, the largest at five thousand tons. Let us suppose, by way of fixing our ideas, that we should build as speedily as possible, twelve First Rates, of five thousand tons displacement; twenty Second Rates of four thousand tons; and twenty Third Rates of three thousand tons; all "frigate built," swift, and armed with as many rifled guns as they could properly carry. These fifty-two ships, if of equal or nearly equal speed, would form a homogeneous fleet—economical in peace, formidable in war.

Half of them cruising at any one time, distributed among our various stations and supplemented by whatever we now have that can be called fit to cruise, would give us all that in the present state of our commerce can be thought necessary. At first the new ships should be spared at the expense of the old. Those should cruise constantly till worn out, the place of each being then supplied by a new one designed to harmonize as far as possible with those already built, but, of course, embodying all the latest improvements in naval architecture up to the time of laying her down.

A sufficient number of such ships as I have indicated having been secured, our attention could profitably be turned to devising and constructing new ships of small size, that could perform the work required of them in a more efficient and economical manner than is possible with our present type.

In laying stress on the desirability of building our ships so as to form a homogeneous fleet, I do not do so with any idea that the fleet fighting of the days of Rodney and Nelson is ever to be seen again. That is to say, I do not think it probable that fleets of fifty or sixty sail will ever again be fitted out to cruise for an enemy similarly concentrated, and that general actions between fleets of that size will again occur. But it will often be desirable for a limited number of ships to operate together, or to concentrate for mutual protection, and if two such squadrons of opposing forces should meet, a fleet action would of course ensue. It is, therefore, it appears to me, eminently desirable that all our new ships should be so alike in speed, armament and general type as to be able to operate together effectively whenever a number of them are in company.

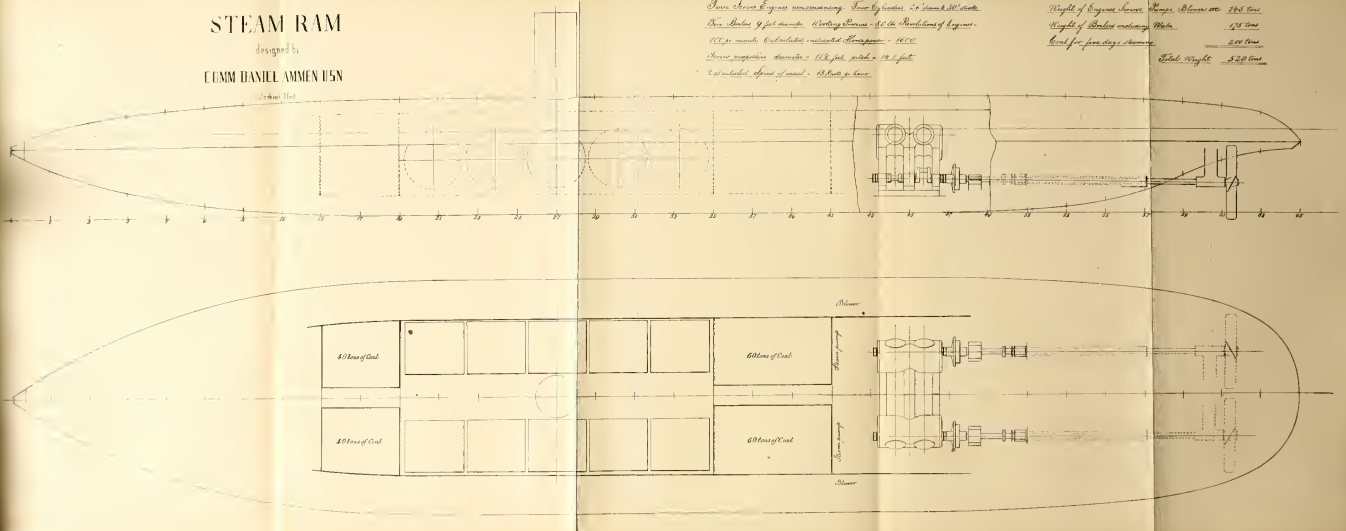
But, not to prolong my paper to an unreasonable length, we must come to a consideration of what is required of us in the way of coast and harbor defence and the best means of meeting these requirements. I have already indicated the character of the work that the navy will be called upon to do in this line and my belief that our best means

for performing it satisfactorily will be found in a fleet of floating batteries, rams and torpedo-boats.

In our floating batteries our aim should be to unite the nearest possible approach to impregnability to shot, with the capability of carrying the heaviest rifled ordnance that can be handled afloat. These chief requisites secured, we should seek such sea-going qualities as will enable them to make short cruises in the waters immediately adjacent to our coasts, and as much speed as the other conditions will allow. So far as I am able to judge, it appears to me probable that these qualities can be most effectively and economically united in vessels of the monitor type; since, with their low freeboard and circular turrets, they appear to offer the maximum protection to their guns with the minimum weight of armor. We need, however, vessels with heavier armor than any now in the service, and a radical departure from the muzzle-loading smooth-bore to the breech-loading rifle, as has been repeatedly urged by the present eminent chief of the Bureau of Ordnance.

For torpedo-boats the essential qualities seem to be speed aud handiness, with the least possible exposure of surface to the enemy's shot. It appears to me that the lighter they are built, the better. The best type of boat for this purpose remains, I think, yet to be devised. The two we now have are too complicated and expensive, unless it can be shown that they are greatly superior to some more simple form, and that I very much doubt. There is a fine field here for the inventive genius of our officers, for a good torpedo-boat is certainly a thing much to be desired. We may, however safely, leave this matter in the hands of those who have made it a special study, in full confidence that they will in good time give us something equal at least to anything that can be produced elsewhere.

I mention as the last, though I consider it really the chief, element of our coast defence fleet, the marine-ram. For an efficient ram the essential qualities are speed, handiness, great strength of construction and a practical invulnerability to shot, to be secured either by heavy armor or by such form as will offer the least surface and most unfavorable angle to the enemy's projectiles. All these are most admirably united in the type proposed by Rear-Admiral Ammen. This proposed ram so perfectly fitted for its intended purposes, is not generally known in its details to the service, and I therefore give a brief description of its principal features from data kindly furnished me, in response to my request, by its distinguished projector.


STEAM RAM
designed by
COMM DANIEL AMMEN USN
Twin Screw Engines non-condensing. Four Cylinders 20" diam & 30" stroke
Ten Boilers 9 feet diameter Working Pressure - 80 lbs Revolutions of Engines -
100 per minute Calculated indicated Horsepower - 1600
Screw propellers diameter - 11½ feet pitch = 14 5 feet
Calculated Speed of vessel - 13 Knots per hour
Weight of Engines Screws, Pumps, Blowers etc 145 tons
Weight of Boilers including Water 175 tons
Coal for five days steaming 200 tons
Total Weight 520 tons
40 tons of Coal
40 tons of Coal
60 tons of Coal
60 tons of Coal
Steam pump
Steam pump
Blower
Blower

An idea of the general shape of the craft may, perhaps, be best conveyed by calling her cigar shaped. That is, she approximates the spindle form, though none of her sections are circular. Her cross sections are formed by two semi-ellipses, the deeper one forming the bottom below the line of greatest beam, the other forming the top above it. The longitudinal section shows a straight middle body of forty-eight feet on each side of the center ; beyond that the ends taper, enclosed by parabolic curves. From this it will appear that, when in the water, the exposed surface will show what is familiarly known as a "turtle-back." The body of the craft is entirely of iron, with a double skin, divided into compartments by nine water-tight bulkheads. Commencing at about three feet below the deep load line the body of the craft is sponsoned out with oak. This sheathing of oak is carried about three feet below the water-line and entirely over the top of the vessel. It is three feet thick at the apex of the sponson, when it forms a sharp angle, diminishing, of course, in thickness towards the ends as well as towards the crown and below the water line.

This oak affords a backing for plate armor, three inches thick from the apex of the sponson to two feet above the load-line, and thence decreasing to one and one-half inches at the crown of the deck. In construction the longitudinal and transverse bracket-frame systems have been combined in such a way as to produce a vessel of most extraordinary strength. There are twenty longitudinal frames built up of plates, butt-straps and angle-irons so as to form continuous girders running from one end of the hull to the other, while at intervals of thirty-six inches, transverse bracket-frames bind the whole firmly together.

At the bow all the longitudinal frames converge and are secured directly to arms cast on a solid head of crucible steel which is the snout of the ram, forming a punch so situated as to strike an enemy's vessel about two feet below the water-line. It will be seen that this construction is such as to distribute at once the shock of collision over the whole body of the ram in such a way as to avoid undue strain on any one part, and to reduce to a minimum the danger of damage to the ram itself. A novel and valuable feature of the snout of the ram is that the apex, on which the main force of a blow will fall in ramming, is easily removable, so that a new one can be readily substituted in case of damage.

Another novel feature of the ram is her pilot house, which being the only part so exposed as to be likely to be injured by shot, is rendered

impregnable by being built up of concentric rings of crucible steel twenty inches in thickness.

The dimensions proposed for the experimental vessel are as follows:

| | |
|---|---|
| Length, - - - - | 205 feet. |
| Breadth. - - - - | 30 " |
| " over sponsons, - - | 36 " |
| Depth, - - - - | 18 " |
| Light draft, - - - | 11 " |
| Load " - - - - | 13 " |
| Displacement, - - - | 1500 tons. |

To give her handiness she is to have twin screws 11½ feet in diameter. If it be found advisable, the Mallory propeller may be substituted. This enables a vessel to reverse instantly and go astern as fast as she can go ahead. The calculated speed of the craft is thirteen knots, but a speed of fourteen is thought entirely practicable. She carries two hundred tons of coal, sufficient for five days full steaming, and has good accommodations for the four officers and sixteen men necessary to man her. Her cost is estimated at four hundred thousand dollars.

To show the extraordinary strength of this craft it may be stated that calculations from the original plans showed that if the hull were supported upon piers, at two points only, one hundred and fifty feet apart, it would sustain, in addition to its own weight, a load of four thousand five hundred tons placed half-way between the points of support. This strength was thought entirely in excess of any possible requirement, and the designs were therefore modified by taking out several girders and reducing generally the weight of the parts. But as now proposed, if she were placed as the span of a bridge, on two piers one hundred and fifty feet apart, the heaviest freight train could be run over her with perfect safety. After this description, no argument can be necessary to show the wonderful effectiveness and economy which this type of vessel promises.

In regard to the number of monitors, rams and torpedo boats that would be likely to suffice for the proper protection of our coasts, it would be difficult to arrive at any very definite conclusion. On our sea-coast we have many places of importance, widely separated. Before any one of these, during war, an enemy is likely to appear suddenly at any time. We should therefore have a sufficient number of vessels for coast defence, to distribute in respectable numbers, in the immediate vicinity of each place of importance. We cannot rely upon protecting Charleston or Savannah with a fleet of iron-clads at

New York, nor New York with a fleet stationed on the New England coast; for, while reënforcements were arriving, the threatened place would be taken. These considerations seem to render necessary a number of coast-defence vessels large in the aggregate, otherwise the squadrons into which it would be necessary to divide them, would be so small as to be in danger of being destroyed in detail. The rams and torpedo-boats would cost comparatively little, and if constructed mainly of iron, as they should be, they could be hauled up on ways at convenient places and housed over. They would thus suffer no great deterioration, and would always be ready when wanted in any sudden emergency.

Considering the extent and character of our seacoast on the Atlantic and Pacific, I would say that the least number with which the country could feel reasonably secure would be forty thoroughly formidable monitors, with twenty-four rams, and twenty-four torpedo-boats.

Gentlemen, I esteem it a great compliment to have been invited to appear before you, and I owe you many thanks for the patience with which you have listened to so long an exposition of my ideas, which, after all, are not new, and I fear, may be of little value. But I have been impelled to lay them before you by the belief that it is only by "line upon line, precept upon precept, here a little and there a little," that the country is to be awakened to a realization of the decay of our strength as a naval power.

I cannot believe, notwithstanding the motto so conspicuous on our new coins, that the nation has entirely settled down to a resolve to trust in Providence to deliver it by main strength from all the mishaps into which it may fall.

I believe rather that the general sentiment of our countrymen is that "God helps those who help themselves" and that ere long, if we do our duty in keeping the facts before the public, a re-action in favor of an efficient naval establishment will set in. It will then remain for us so to use the means provided as to hand down to coming generations a flag as unsullied, an example as noble, a record as glorious as have been bequeathed to us.

Rear Admiral AMMEN. I desire to say a few words in relation to the Ram after the kind manner in which it has been presented by my friend Lieut. COLLINS.

Coming home from China nearly ten years ago, it occurred to me that our Navy was gradually falling to pieces; that its condition was such as to give every old officer great concern for the maintenance of ourselves in the event of a war. The first idea was to look to torpedoes; on going to Newport it seemed to me that although those able officers had produced what seemed wonderful results, at the same time that there would be great embarrassment in the practical application of torpedoes upon an enemy well prepared; therefore instead of carrying out the conception of a torpedo boat that I had already begun, I set to work on a ram designed to have immunity in a great degree from shot and shell. I enlarged upon my first design and with the aid of some gentlemen, one of whom was Lieut. Wood, a very able young officer, and with the assistance and advice of officers here and there I embodied something that seemed to possess the elements of strength to ram and resistance to shot, with qualities that would enable her to meet an enemy in broad daylight. If we cannot meet an enemy when he looks at us I do not think that we have a Navy that can be depended upon.

After the displacement and weights of materials had been twice computed and specifications made sufficient to admit of a fair consideration of her elements by a Naval Constructor, I did not fail to ask the assistance of the ablest that I have known; had I the right to mention his name, I feel sure that his efforts, if not mine, would command your confidence. The Ram, as presented in calculations, specifications and drawings, has undergone the careful revisal of one of the ablest Naval Constructors, indeed in my belief the ablest, that our country has produced. Whatever alterations have been suggested have been made, so that substantially it is not the work of an amateur or person unskilled in such matters.

The Engineer-in-chief kindly aided too, and had calculations made which indicated that when loaded to a water line at the greatest beam of the vessel her co-efficients showed extraordinary capacity for developing speed, and even when at her fighting depth, (two feet greater draught) a speed of 13 knots would be obtainable.

She has been looked at also by another Engineer of rank and ability who had been abroad and had been shown in the English Admiralty a design apparently identical in construction and measurements, except an increase of two feet of beam. This Engineer, whom I do not feel at liberty to name, after giving some calculation and consideration to the matter thinks a yet higher rate of speed obtainable than that already named.

In permitting these papers to be laid before you it is understood that I do not pretend to be a Naval Constructor, nor would I submit them with confidence had they not undergone a close scrutiny and amendment which I think will be found sufficient to entitle them to your consideration and confidence.

Rear Admiral JOHN RODGERS (the President). The officer who has just read his paper to us thinks that future cruisers will be wooden vessels. I have, for some time, thought as he does. Formerly, in armies, armor and guns were pitted against one another; finally, guns won and armor was thrown aside. Ajax had a shield of seven bulls' hides, which no spear could pierce. Then men found that iron armor was lighter, and as efficacious. In armor of proof they defied sword and arrow and spear. Gunpowder was invented, and while the armor at first resisted the bullets on account of the crudeness both of guns and powder—as these became better, the Knight was forced gradually to increase the strength and consequent weight of the armor, until at last he was borne down, but no longer protected. Then he threw off his armor and fought lightly clad.

What has happened to personal armor will happen to ships. Now, they

make guns so large that no armor which can be carried to sea is able to resist the shot. The logical end of armor has been reached. It encumbers, but will not protect. The time is not far off when armor will be thrown away, and light wood or iron substituted. Protection will be found in many compartments. Geometers have found in analyzing the shape of the honey-comb that the hexagon used in them gives the greatest possible capacity with the least expenditure of material. Geometrically, hexagonal compartments would be the best; in practice, this shape however may offer too great difficulties. But many compartments will make the vessel safe. With enough of them a ship may have two or three shot pierce her below water, or be blown up with two or three torpedoes, and still swim, still fight, and still possibly carry her enemy into port.

The CHAIRMAN. I am quite sure that all present at this meeting will agree with me that our thanks are due to Lieut. COLLINS for the very interesting and admirably written paper, which he has read to us to night. The subject—a difficult one—and one upon which there will always be more or less difference of opinion, has in my judgment been ably discussed, leading toward that unity which is so essential to final good results. What we have long wanted is a general agreement as to the real requirements in building up such a Navy as this country needs. Money, although indispensable, cannot alone accomplish the object. Thoroughly considered and well digested plans, prepared by professional experts and carried out under their personal supervision, by faithful skilled laborers, can alone save the Navy in the dark day of trial, from disgrace. At present the Department has no money to carry out any general plan of regeneration, and I think it is better that no money should be expended on any general idea of increase of material, until some practical and practicable programme has been determined upon. The great misfortune, it seems to me, has been, of late, the absence of professional influence and judgment in our naval constructions, and the necessarily consequent waste of money. It has been a kind of "the blind leading the blind," purely and simply for want of well considered plans and needs. There is little use of having highly educated and experienced officers, and well drilled Seamen gunners, when called to meet an enemy, if they are not provided with the most efficient vessels and the best ordnance that can be fabricated—at least equal to the ships, ordnance and other appliances of war, of those with whom they are to, (or are most likely to,) come in contact.

I hope the meeting will, by vote, give its thanks to Lieut. COLLINS for the agreeable entertainment the reading of his excellent and admirably prepared paper has afforded us this evening:—I make that motion.

The motion was seconded, put, and unanimously carried.

Lieut. COLLINS. I am obliged to the gentlemen of the Institute for the kind manner in which they have received my paper and to the Chairman also for the complimentary way in which he has spoken of it. I wanted to bring out one idea in the paper and if I did not bring it out clearly there I shall try to do so now, and that is this; that it is our duty as Naval Officers to teach the public what they need in the way of a Navy. We are the experts in this matter and they look to us to tell them of our needs, and if we fail to do so we fail in our duty. The time will come when we will have a war on our hands, and if we are not better prepared then than now, we shall come to grief. If we then say "we have no ships, no effective ordnance" the Country will reply "You should have said so before while there was time to prepare them." I think that we ought not to lay ourselves open to that reproach, but that we should tell the country what we need, and insist upon it until we get it.

# THE RECORD

OF THE

# UNITED STATES NAVAL INSTITUTE.

NAVY DEPARTMENT, WASHINGTON,

MARCH 13, 1879.

Captain SAMUEL R. FRANKLIN, U. S. N., in the Chair.

## THE NAVIGATION OF THE CHINA SEAS.

By LIEUTENANT ZERA L. TANNER, U. S. NAVY.

### INTRODUCTORY REMARKS.

I have been requested by the committee to prepare a paper on the navigation of the China seas. I have consented to do so, notwithstanding the fact that it must necessarily be a dry subject to all, except those who are familiar with the intricate and dangerous navigation of its waters.

A paper of this kind must of necessity abound with names of Eastern origin, entirely unknown and without significance to those unacquainted with the language, or localities.

The discussion of winds, weather, and routes, to which this paper must be confined, will be of little interest except to the navigator, and, unless he is familiar with the various routes, he will find it difficult to follow me through the devious courses necessary to take in traversing this sea against an adverse monsoon.

I shall make no excuse for occupying your time this evening in discussing so dry a subject. If not particularly entertaining, it is of great importance to all who have the responsibility of conducting our ships through those dangerous waters.

The main routes are becoming pretty well known, but there are many localities to which vessels are frequently obliged to resort, from stress of weather or other causes, of which we know little or nothing, and to add to the difficulties and dangers of navigation, our charts are very imperfect, a large portion of the Eastern seas being but partially known, and imperfectly surveyed.

My experience in this region is confined to thirty-five trips up and down, or across, the China sea. During this time I may have gained some information that will be of service to those who have not been over the ground, or whose experience has been less than mine.

It will be seen that, in numerous instances, my conclusions differ from standard authorities, and may provoke discussion which will tend to increase our knowledge of one of the least known and most frequented of the great ocean routes of the world.

In preparing this paper I am indebted to

The China Sea Directory, British Admiralty;

The North Pacific Directory, Findlay;

Navigation of the Pacific Ocean, Becher;

the information thus obtained being supplemented by personal recollections and frequent reference to my Remark books.

## Navigation of the China Seas.

The prevailing winds in the China sea and its approaches, exert a more marked and direct influence on its navigation than over any other of the great ocean highways.

This influence is felt to such an extent that entirely different routes have to be adopted, and in some cases it has been found advisable to sail around the entire region embraced within the limits of the China sea in order to reach port against an adverse monsoon.

Before the days of clipper ships it was customary to so plan the voyage that a fair monsoon would be carried both ways. An attempt to beat up the China sea against the N.E. monsoon would have been considered a feat worthy of the Flying Dutchman.

The native trading junks made but one voyage a year, always going with a fair monsoon, never dreaming of the possibility of beating against it. So firmly were the Chinese merchants impressed with the impracticability of making a passage safely against the monsoon, that for years after clipper ships began to ply on their coasts they would not ship by them, preferring—as they supposed—the safer means of transport by junks, as they waited for a fair wind.

For nearly two centuries the Dutch at Desima, were permitted to receive and despatch one ship a year, and her voyage was so timed as to meet a favorable monsoon both ways.

The first vessels to regularly beat up the sea, were the opium clippers, generally brigs or schooners, well manned and designed to attain the greatest possible speed.

## Monsoons of the Java Sea.

The strait of Sunda, through which passes a large proportion of the enormous commerce entering the China sea, lies in the region of the S.E. and N.W. monsoons; the former prevails from May to October, the latter from November to March, extending over the Java sea, and through the straits of Banka, Gaspar, and Carimata. The times of change and direction in the straits are uncertain, and calms are frequent at all times during the S.W. monsoon. The winds in Banka strait usually follow the coast-line, subject to slight variation from land and sea breezes.

## Monsoons of the China Sea.

The S.W. monsoon commences in the China sea from the middle to the latter part of April, and continues until about the middle of October. It usually sets in earlier in the Gulf of Siam and Tong King than in the open sea, or on the coasts of China, Palawan, and Luzon, and continues longer in the southern than in the northern parts, southerly winds frequently prevailing about Singapore after the N.E. monsoon has set in farther north.

The S.W. monsoon is usually light and unsteady during the first month, attaining its full strength during June, July, and August, when it is most steady. S.E. winds are not uncommon, however, at any time during this monsoon.

Heavy rain squalls and cloudy weather may be expected in June, July, and August. White squalls are occasionly met with during the month of May, in the vicinity of the Gulf of Siam, and black squalls at any time during the S.W. monsoon.

These squalls, owing to their violence, and the suddenness of their appearance, are among the greatest dangers of this locality, and can be guarded against only by the strictest vigilance. Caution is unnecessary to those who are familiar with them, but I wish to impress upon those who are not the vital importance of employing the brief interval of warning in preparing to meet it, if under sail, by leaving as little canvas as possible exposed.

They frequently appear during clear, pleasant weather, when least expected, a few moments' warning being given by the rapid rising of a dense cloud.

The first experience of an officer with one of these dangerous blasts is liable to result in serious loss of sails and spars—the inevitable result of a little delay to see what it is going to amount to. With the

exception of the squalls mentioned, heavy gales are rare in the gulf. Moderate gales are frequently met with on the east coast.

Land and sea breezes prevail near the coast, from Siam to the Gulf of Tong King, during the S.W. monsoon. To the northward of Hong Kong this monsoon cannot be said to fairly set in before May, and even then it is frequently light and variable, N.E. and S.E. winds blowing for days at a time between Hong Kong, Formosa, and the Loo Choo Islands. It is usually light near the west coast of Formosa, being greatly modified by the high land of the island. They are stronger in mid-channel and near the China coast, but are liable to alternate with N.E. winds at any time.

Dense fogs, with misty, rainy weather, are of frequent occurrence in June, July, and August, greatly increasing the dangers of navigation. I have frequently observed, however, that objects are visible at considerable distances close in shore when an impenetrable fog prevailed at sea. It is not an unusual occurrence for a steamer to make the trip between Hong Kong and Turnabout Island without seeing land.

In the latter part of May, 1877, the " *City of Peking*" left Hong Kong and steamed up the coast, through the Formosa strait, and across the sea to the Linschoten islands without seeing land or lights.

The black northeaster is a storm peculiar to the region about the northern entrance of Formosa straits. We encountered one in May, 1877, so remarkable in some of its features that I consider it worthy of notice here.

We were sixty miles east of Turnabout Island, at noon, with a moderate breeze from S.W., thick, hazy weather, barometer steady at 29.89, thermometer 80°. A dense black bank was visible to the northward. The S.W. wind died away suddenly at 2.55 P. M.; the black bank, having nearly reached the zenith, entirely obscured the northern heavens. Five minutes later the wind came out from N.E. in a furious squall, with torrents of rain, and incessant thunder and lightning ; the entire forces of the heavens were seemingly concentrated above and around the ship. The darkness was so great for a few minutes, that it was exceedingly difficult to distinguish points of the compass in the binnacle, and the mist was so dense that neither bow nor stern could be seen from the bridge. The compasses were perceptibly affected previous to and for a few minutes after the storm burst upon us. The barometer commenced to rise immediately, and the thermometer fell 10° in as many minutes. At midnight we had a strong wind from N.E. by N., with thick, rainy weather, barometer 30.02, thermometer 67°.

## North East Monsoon.

The N.E. monsoon in the northern part of the China sea, usually sets in about the latter part of September, and is blowing steadily in November, increasing in strength during the months of December and January, accompanied with cloudy, rainy weather, frequent gales and heavy seas alternating with short intervals of fine weather.

The region from the north end of Formosa to the coast of Japan, has generally been considered within the limits of the monsoons.

It is an undoubted fact that the prevailing winds are from the northward during the prevalence of the N.E. monsoon, but I have frequently found it blowing from other quarters for days at a time.

## Winds on the Coast of Japan

The coast of Japan from Cape Satano to the Gulf of Yedo has been mentioned also as within the limits of the monsoons. From my experience of this locality I would assign it to the region of variable winds.

The following table is a compilation of the winds experienced by the "*City of Peking*" during fourteen trips between Hong Kong and Yokohama. The route is divided into three sections, showing the prevailing winds in each.

### FROM HONG KONG TO TURNABOUT ISLAND.

| Months. | Hours. | Nd. Hours.—Force. | Nd & Ed. Hours.—Force. | Ed. Hours.—Force | Sd. & Ed. Hours.—Force. | Sd. Hours.—Force. | Sd. & Wd. Hours.—Force. | Wd. Hours.—Force | Nd. & Wd. Hours.—Force. | Var. H'rs. | Calm H'rs. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| January | 114 | 54–4–6 | 60–5–6 | 0–0 | 0–0 | 0–0 | 0–0 | 0–0 | 0–0 | 0 | 0 |
| February | 116 | 10–3–2 | 85–6–4 | 9–4 | 0–0 | 0–0 | 6–4 | 6-4 | 0–0 | 0 | 0 |
| April | 34 | 0–0 | 0–0 | 0–0 | 0–0 | 24–1 | 10–2 | 0–0 | 0–0 | 0 | 0 |
| May | 70 | 33–4 | 0–0 | 33–4-2 | 0–0 | 0–0 | 0–0 | 0–0 | 0–0 | 4 | 0 |
| June | 33 | 0–0 | 24–5–6 | 9–5 | 0–0 | 0–0 | 0–0 | 0–0 | 0–0 | 0 | 0 |
| October | 52 | 20–3–4 | 12–3 | 12–3 | 0-0 | 0–0 | 0–0 | 0–0 | 0–0 | 0 | 0 |

### FROM TURNABOUT ISLAND TO CAPE SATANO.

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| January | 173 | 78–4–7 | 64–5–6 | 0–0 | 0–0 | 0–0 | 1–7 | 12–4 | 18–4–5 | 0 | 0 |
| February | 152 | 56–5–6 | 28–5 | 4–1 | 48–2–5 | 0–0 | 0–0 | 16–4 | 0–0 | 0 | 0 |
| April | 48 | 0–0 | 0–0 | 0–0 | 8–2 | 28–2 | 4–2 | 8–4 | 0–0 | 0 | 0 |
| May | 114 | 4–4 | 29–4–7 | 32–4–5 | 0–0 | 22–6 | 23–3–6 | 0–0 | 0–0 | 4 | 0 |
| June | 42 | 4–5 | 16–5–6 | 22–4–5 | 0–0 | 0–0 | 0–0 | 0–0 | 0–0 | 0 | 0 |
| October | 138 | 27–4–7 | 43–4 | 20–3 | 9–6 | 0–0 | 3–4 | 0–0 | 34–5–6 | 2 | 0 |

### FROM CAPE SATANO TO THE GULF OF YEDO.

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| January | 141 | 56–4–5 | 33–4–5 | 3–6 | 0–0 | 0–0 | 3–7 | 36–2–5 | 10–5 | 14 | 10 |
| February | 162 | 58–4–5 | 35–3–5 | 0–0 | 4–2 | 8–4 | 4–4 | 14–6–7 | 39–5–7 | 0 | 0 |
| April | 155 | 40–3–6 | 0–0 | 8–5 | 0–0 | 12–6 | 15–5–6 | 40–3 | 28–5 | 12 | 0 |
| May | 120 | 6–6 | 8–1 | 55–2–3 | 4–3 | 7–3 | 6–5 | 32–5 | 0–0 | 4 | 0 |
| June | 45 | 0–0 | 4–4 | 38–4–5 | 0–0 | 3–4 | 0-0 | 0–0 | 0–0 | 0 | 0 |
| October | 216 | 28–3–6 | 97–3–6 | 25–4–3 | 0–0 | 4–2 | 8–6 | 12–2–7 | 24–4 | 18 | 0 |

It will be seen by reference to the above table that the winds between Turnabout and Cape Satano are more variable than those on

the China coast, and from the cape to the Gulf of Yedo, although northerly and easterly winds are most frequent, they are often found blowing from other quarters.

I have frequently observed a great similarity in the winds and weather on this coast, and that in the same latitudes on the east coast of the United States. The directions for the barometer on the latter coast apply quite as well to the southern part of Japan.

### Winds in the Yellow Sea and Gulf of Pechili.

The prevailing winds in the Yellow Sea and Gulf of Pechili are northerly and N.W. during the winter months, with frequent gales from those quarters; S.W. and S.E. winds prevailing during the summer.

### The N.E. monsoon in the middle and southern part of the China Sea

The N.E. monsoon usually sets in a week or two later in the vicinity of Hong Kong than farther to the northward, and in the southern part of the sea variable winds may be expected until early in November.

December and January are stormy months over the whole China sea. The winds moderate in February, and are frequently light and variable in March.

The N.E. monsoon frequently sets in with a fresh gale, and blows for a week or ten days without intermission, accompanied with thick, rainy weather, heavy seas, and strong currents.

The barometer usually gives sufficient warning, particularly in the northern portions of the sea. Numerous instances have been related however of these "monsoon bursts" having been precipitated upon the unfortunate mariner unheralded by the barometer or other atmospheric indications. Serious damage to shipping is the natural result, as many vessels will be caught in exposed positions, or, from various causes, be unprepared for a lengthened struggle with the elements.

### Winds on the Coast of Luzon.

Land and sea breezes prevail on the coast of Luzon in March and April, with fine weather. The rainy season on the west coast is from May to October, while on the east coast it is the dry season.

Northerly winds set in about the middle of October bringing the wet season on the east coast, with fine weather on the west.

Variable winds may be said to prevail during the N.E. monsoon.

Northerly and N.E. winds are the rule, but strong, steady breezes from the westward are of frequent occurrence.

### Winds on the Palawan Coast.

Local influences are such on the coast of Palawan that it is difficult to tell when the monsoons set in or end. From about December to April N.E. and easterly winds prevail. Land and sea breezes are usually found near the coast in May and June—the finest months in the year.

S.W. and westerly winds with unsettled weather may be expected in July, and August. Short intervals of fine weather being followed frequently by heavy S.W. squalls.

W.S.W. winds prevail in September, and October, usually blowing strongly with dark, cloudy weather and frequent squalls. Variable winds may be expected in November, and heavy gales are frequent.

### Typhoons.

The typhoons of the China sea are cyclonic gales, ranging over the Philippine islands, Bashee channel, east coast of Formosa, the Japan islands, and a considerable portion of the North Pacific ocean.

It is said they do not extend into the Formosa channel, and as we have the record of but two at Amoy, it would seem that their appearance in that locality was extremely rare at least.

The Amoy typhoons occurred in August 1864, within a few days of each other—one traveling to the northward and westward, the other to the southward and westward; both evidently having entered the China sea in the vicinity of the Bashee channel. They visit Shanghai and the Chusan islands at long intervals.

These destructive hurricanes seem to have their origin in the region of the Eastern archipelago, Borneo, and the Philippine islands.

Their general track is to the westward, to the coast of China, or, recurving, they take the general direction of the Japan stream to the east coast of Formosa, the Loo Choo and Linschoten islands, the coast of Japan and the Pacific ocean.

Our data are not sufficient to enable us to lay down absolute rules for determining the track of these dangerous storms, and it is more than probable that their ultimate course is the result of local influences after they have started on their career.

Our present knowledge of the tracks of these storms may be given as follows.

1st. That after their conception they take a westerly direction to-

ward the coast of China, or, recurving, sweep off in the direction of Japan and the Pacific Ocean.

2nd. That a typhoon seldom recurves after entering the China sea, but usually in the region to the eastward of the Philippines.

3d. That if a typhoon strikes the China coast, with a westerly course, it usually goes inland, where its track is lost, seldom recurving to appear again in the China sea.

The typhoon season is from May to December, but they more frequently occur, and are most violent, during the months of June, July, and August. They are not often met in May, nor in December, and when they do occur in those months, are not usually as violent as those from June to August.

Much confusion has resulted from attempts to reconcile the movements of some of the gales occurring about the change of monsoon in October or November with the general rules laid down for typhoons, when they are not typhoons at all, but simply monsoon bursts, or other gales having an entirely different origin and governing principle.

### Typhoon Warnings.

The barometer gives the most reliable information of the approach of one of these dangerous tempests, or, in fact, of any great atmospheric disturbance. There are usually other indications, but without the aid of the barometer they might pass unnoticed. I recollect a case in point which taught me to respect the marine barometer. We had been becalmed all day just to the northward of Madagascar; the sea was as smooth as a mill pond, and not a cloud to be seen. The heat was intense and exceedingly oppressive. The atmosphere seemed lacking in some vital element, the least exertion being attended with a shortness of breath.

The crew went about their duties in a listless, half sullen manner, and the officers were exceedingly irritable and exacting. Animals that had the run of the decks were restless, and those that had been petted by members of the crew sought out their friends and followed them about as though for protection.

We thought nothing of all this at the time, attributing it to the usual enervating effects of a calm in the tropics.

A light breeze sprung up as the sun went down, filling the sails and giving us good steerage way. It was one of the most beautiful evenings I ever saw, the stars shone with unusual brilliancy in the cloudless sky, and although there was no moon, everything could be distinctly seen about the decks and aloft.

The only peculiarity remarked at this time was that the slightest noise attracted attention, and ordinary conversation was audible from one end of the ship to the other. At 8 o'clock the Captain ordered the light sails in, and the yards sent down; the order was executed, but there were many grave conjectures among the crew as to the commander's mental condition.

Sail was reduced until the ship was under close reefed topsails and storm staysails, everything securely lashed about the decks, hatches battened down, and every preparation made for a gale. There was a moderate breeze at midnight, and apparently settled weather. At 4 A. M. a moderate gale, and at 8 A. M. a hurricane! the ship under bare poles.

The captain by closely observing the barometer during the day and evening was perfectly aware of the approaching storm, and while the rest of us were discussing the doubtful policy of shortening sail in fine weather and a fair wind, he was deliberately preparing his ship to meet it.

In the tropical portion of the China sea the barometer is not always reliable in indicating local changes, and apparent anomalies in its action are frequently noticed, tending to destroy the confidence of the navigator in one of his most useful instruments. If not very sensitive to unimportant local changes, it will invariably indicate great atmospheric disturbances such as typhoons.

Complaints have been made that the warning is at times very short. When we consider the fact that the storm is advancing two hundred miles, or more, in twenty-four hours, it may be easily conceived that, under certain conditions, the atmospheric disturbance would not be very far in advance of the actual storm.

As a matter of fact, forty-eight hours is not an unusual warning in the China sea. Twenty-four hours is the rule, and less than twelve hours is rarely known.

No vessel should encounter a typhoon at sea, if it is possible to avoid it. If there are no harbors available, sea room should be gained while able to carry sail; the second consideration being to get as far from the vortex as practicable. It will frequently happen that in accomplishing one object the other will be attained.

If a typhoon is encountered in the act of recurving it may be very difficult to determine which way it is moving. The only thing to be done in this case is to watch the barometer and wind until the general direction of its path is ascertained, then act according to circumstan-

ces. When the storm is advancing in a direct line it is usually a simple matter to ascertain the bearing and approximate distance of the vortex.

Instances have occurred where vessels in the track of a typhoon, and standing directly toward it, have been led into the belief that it was a direct gale, because the wind did not shift, and were thus enticed into the vortex. This was the case with the U. S. S. "*Idaho*" off the coast of Japan.

### Currents of the China Sea and adjacent waters.

The currents of the China sea usually take the direction of the prevailing monsoon, frequently modified by land, shoals, or other causes, some easily accounted for, others simply unaccountable. The uncertain currents of the Eastern seas add greatly to the difficulties and perplexities of the navigator.

### The Kuro Siwo, or Japan Stream.

The great oceanic current called the Kuro Siwo, or Japan Stream has its origin in the N.E. trade drift of the Pacific ocean, between the parallels of 10° and 20° north latitude; taking a westerly course until it reaches the Philippean islands, where it is deflected to the northward, forming, near the northern end of Luzon, what may be considered the head of the Japan stream.

Sweeping along the group of islands to the northward of Luzon, a portion finds its way through the various channels, and, impinging upon the east coast of Formosa, is again deflected towards the coast of Japan, the northern verge reaching the latter coast about Cape Satano, and sweeping through Van Diemen strait with great force.

It attains considerable breadth in this locality, passing through the Linschoten, and Loo Choo islands, where its velocity is greatly decreased, and its limits not well defined.

It takes an E.N.E. direction from Van Diemen strait, attaining its maximum force on a line drawn from the latter point to the vicinity of Oö sima, thence to Rock Island. From the latter point to Cape Sagami, inside of Vries island, regular tides prevail. They are greatly affected but rarely overcome or entirely neutralized by the stream.

Passing Cape King, where it has an approximate breadth of two hundred miles, it separates, one branch taking a N.E. by E. direction, the other south easterly towards the Bonin islands.

### Portsmouth Breakers.

The Portsmouth breakers were first reported by the U. S. Ship of

that name, and were placed in latitude 34° 13′ 00″ N., longitude 138° 17′ 00″ E. As they have proven to be the result of currents it may not be out of place to mention them here.

Of all the reported dangers in the Eastern seas, none have caused as much anxiety and perplexity to the navigator as that above mentioned. The report of their existence in this locality, coming from the most reliable authority, and, their position being directly in the track of shipping, the spot was most religiously shunned at night and eagerly sought in daylight.

Ship after ship searched for it in vain, and reported that the breakers did not exist. Then would come reports from vessels at long intervals that they had seen them, and the search would be resumed, with the same result.

On the 5th of June, 1868, the U. S. S. "*Onward,*" from Nagasaki for Yokohama, laid a course to pass over the position assigned them on the American chart of that day.

They were sighted from the masthead at 2.30 P. M., about ten miles distant. The weather was clear—a brisk breeze from N.W. and moderate swell.

We held our course until they were visible from deck, then hauled up a point to pass to windward. As we had a commanding breeze it was decided to take a line of soundings in passing. With this object in view, we ran down to within three cables of the western end, and were about heaving to for a cast when we discovered ourselves drifting rapidly towards the breakers, which extended about five miles in a W. N.W. and E.S.E. direction.

We made all sail and hauled up to N.E. We now found ourselves in a heavy swell, the ship rolling violently and still losing ground. We then hauled by the wind heading N.N.E. and just held our own until finally drifting past them, when we resumed our course.

The height of the breakers was variously estimated at from fifteen to twenty feet.

Upon our arrival in Yokohama the circumstance was reported, and the U. S. S. "*Monocacy*" went out to search for them, but saw no breakers.

It is undoubtedly an *overfall* occurring at long intervals, and lasting for a short time only. I have passed over the position eighteen times since then, in all weathers, without seeing the least indication of danger.

### Passages into the China Sea.

Vessels bound from America or Europe to Batavia, Singapore, Siam,

and China, will enter the Java sea through Sunda strait. The same may be said of those bound to Japan, although at certain seasons, some of the Eastern passages might be preferred.

Banka, Gaspar, and Carimata straits lead into the China sea. Either may be selected, but the choice lies practically between the two former, the latter possessing no advantages to a vessel bound up the sea.

Banka strait is undoubtedly the safest, and in this respect has great advantages over Gaspar or Carimata.

Since the recent British and Dutch surveys of Banka strait it may be safely considered the most accurately mapped of any portion of the Eastern seas. It is of much greater length than Gaspar, and not so direct, but its approaches are easy and safe, and good anchorages can be found through its entire length, enabling a ship to take advantage of winds and tides.

Vessels entering the China sea through this strait escape the dangers encountered in the approaches to Gaspar, and during the N.E. monsoon, they will gain considerably to windward in smooth water.

## Gaspar Strait.

Gaspar strait is extensively used by vessels bound to China direct, and under certain circumstances, has advantages over other routes. It is shorter, more direct, and with fine weather and favorable winds, time will undoubtedly be gained by using it.

On the other hand it cannot be approached at night, or in thick weather, without great risk. It was surveyed by officers of the U. S. Navy in 1854, but time did not admit of a thorough examination of the approaches.

There has been but little hydrographic work done ,in this locality since that time. What little knowledge we have gained, has been from ships whose wrecks marked, for a brief period, the numerous reefs and shoals that to-day bear their names.

This kind of exploration has serious disadvantages, not only from the loss of property, but from an uncertainty as to the exact location of the discovered dangers. The perilous position of a vessel suddenly stranded upon an unknown reef is not conducive to accuracy in observations for its location.

Vessels bound down the China sea, particularly during the latter part of the N.E. monsoon, usually pass through this strait, notwithstanding its dangerous approaches, and will continue to do so, for the

simple reason that time is gained, which, to a homeward bound ship with a valuable cargo—the first of the new crop of teas for instance—is a matter of vital importance, and compensates in a certain measure for the extra risks.

### Carimata Strait.

Carimata strait is the easternmost of the three principal channels leading from the Java to the China sea. Although broader than either Banka or Gaspar, it is quite as difficult of navigation, owing to the fact that it has never been well surveyed.

The positions of many dangers have been determined by officers of the British and Dutch Navy, but there has been no thorough or connected survey, and many dangers are still unknown, or imperfectly placed on the chart.

Vessels frequently use this passage when bound from Singapore strait to China by the Eastern passage, and occasionally by homeward bounders, when, from the effects of winds and currents, they find it difficult to hold their course far enough to the westward to enter Gaspar strait.

Under the above conditions it might be advisable to take this route, depending upon a vigilant lookout and other precautions well known to the navigator, rather than upon the charts, which are well known to be unreliable.

### Malacca Strait.

Malacca strait would be used by vessels bound from Ceylon, or the Bay of Bengal, up the China sea. It is well surveyed, and the channels generally of good width, with excellent anchorages.

### Passages up the China Sea.

Having entered the China sea by any of the above passages, bound to Hong Kong, or ports to the northward, we have the following routes from which to select.

### The Inner Route.

The inner route lies to the westward of the Anamba islands, to Pulo Condore, along the coast of Cambodia, Cochin China, and Hainan. It may be used to advantage during the latter part of the N.E. monsoon, in March, April, and May, by sailing vessels and steamers of small power. They will have smoother water than in the open sea, less current, and variable winds.

### The Main Route.

The Main route lies to the westward of Anamba islands, to Pulo

Sapata, the Macclesfield banks, and thence to Hong Kong.

This is the general route during the S.W. monsoon, and is by far the most simple navigation in the China sea. It is seldom used during the N.E. monsoon except by full powered steamers. The English and French mail steamers take it from Singapore to Hong Kong.

Sailing ships have used it also, but the wear and tear is so great that it is not advisable unless the anticipated results are sufficient to compensate for extra risk and expense.

None but the best Clipper ships would attempt it, and even they—after a brave battle with strong head winds, adverse currents, and turbulent seas—have frequently been obliged to bear away in a crippled condition, seeking milder weather in one of the Eastern passages.

### The Game Cock's passage up the China Sea.

The American Clipper ship "*Game Cock*" left Batavia October 18, 1859 for Shanghai, with a valuable cargo, under guarantee to deliver it within 60 days. Large freights were offered, but no other ship in port would accept it with the conditions imposed. It was considered a hazardous enterprise and the general impression among ship-masters was that she would not make the passage in the time specified.

Variable winds and squally weather were experienced in crossing the Java sea. Gaspar Strait was passed on the 22d with moderate westerly winds, and fine weather.

The N.E. monsoon was encountered on entering the China sea; moderate at first and increasing rapidly as she went to the northward.

The route to the westward of the shoals was taken—the old route of the opium clippers—thence to Formosa, passing to the eastward of the island on the 28th of November, arriving in Shanghai, December 9, fifty-two days from Batavia.

We were usually under single or double reefs after passing Natuna and Anamba islands; from 8° to 22° N. latitude the ship was literally under water. Nearly everything movable on deck was adrift at one time or another during the trip, and it was with the greatest difficulty that we could keep the hatches securely battened.

The weather was usually overcast and misty, with frequent rains, heavy, turbulent seas, and strong southerly currents. Two or three days frequently passed without observations.

The experience of the "*Game Cock*" may be taken as a fair average from November to February, and as she was one of the most weatherly of all of the famous clippers of her day, it will be seen that

the task she accomplished, after a desperate encounter with the elements, should not be attempted except by the ablest ships, perfectly appointed for their work.

### The Palawan Passage.

A vessel taking the Palawan passage would sight Low island, pass between the Natunas, north of Luconia shoals, through Palawan passage, up the coast of Luzon to Piedra point, thence to port, passing usually, to the southward of the Pratas.

This route is generally used during the N.E monsoon, from the latter part of October to March, by sailing ships and steamers of small or moderate power.

Vessels of the above class entering the China sea, through Banka strait, and finding the monsoon at its height, may escape much rough weather by taking Rhio strait, or even Varella, Durian, and Singapore straits, gaining considerably to windward in smooth water, with good anchorages available, enabling them to take advantage of tides and favorable winds.

Monsoon gales are frequent from December to February, particularly at the time of new and full moon, lasting two or three days with thick, rainy weather, turbulent sea, and a southerly current of fifty to seventy miles per day. Should a vessel encounter one of these gales upon her arrival at the eastern entrance of Singapore strait, it would be advisable to anchor until it moderates, when the wind will probably veer to the northward, or even N.W. for a short time, permitting her to cross over to the Borneo coast, without the delay she would certainly have met with had the passage been attempted during the gale.

The route between Great Natuna and Soubi island is preferable for sailing vessels, but if they find it difficult to work to windward, they may take either the Koti or Sirhassen passage.

The Api channel is difficult, owing to the strength and irregularity of the currents, but has been used to advantage by sailing vessels, and is strongly recommended by competent authority for steamers, as, near the Borneo coast, light to moderate winds, and comparatively smooth seas are frequently met with when it is blowing heavily farther off shore.

Smooth water may be expected from Luconia shoals to the northern entrance of Palawan passage.

From the Palawan it is usually considered advisable to make Lubang island; then follow the coast of Luzon at a distance of ten to

twenty miles to Piedra point, or cape Bojeador, when a course may be laid for Hong Kong, passing to leeward of the Pratas, unless the weather is such that the position of the ship can be accurately obtained.

Preparation should be made before leaving the coast of Luzon for carrying a press of sail, as strong winds, turbulent seas, and southerly currents will probably be encountered in crossing the sea. A fair sailer should be able to make Hong Kong, from the northern end of Luzon, without much difficulty.

If bound to one of the northern ports a course should be held to the northward of Luzon, passing through one of the channels between the latter island and Formosa; along the eastern coast of the latter, taking advantage of the Japan stream, thence to port.

### Passage to the Westward of the Shoals.

The passage to the westward of the shoals follows the main route to about 10° N. latitude, then crosses over to the coast of Luzon, skirting the reefs, and reaching the latter coast between Manilla and Piedra point, where it intersects the Palawan route.

This was the old track of the Opium clippers, but in later years it was almost discarded for the Palawan passage.

### Eastern passage from Singapore Strait.

The Eastern passage from Singapore strait leads through Carimata, up the Java sea, through Macassar strait, the sea of Celebes, and Basilan strait, into the Sulu sea; thence along the coast of Mindanao, Negros, Panay and Mindoro; entering the China sea through Mindoro strait, when the route joins that of the Palawan passage.

This route is used to advantage from October to December, by vessels not prepared to meet the heavy weather of the China sea.

N.W. winds may be expected in the Java sea; southerly and westerly in Macassar strait, and easterly in the Celebes and Sulu seas. Variable winds may be met with in the Sulu archipelago and Philippines, and gales from all quarters, with heavy thunder and lightning, are not uncommon.

If it is not desirable to enter the China sea through Mindora strait, a route may be taken into the Pacific Ocean, between Mindanao and Celebes, entering the China sea between Luzon and Formosa.

### Eastern passage from Sunda Strait.

The eastern passage through Sunda strait, the Java sea, strait of Macassar, Celebes sea, and one of the passages between Mindanao and Celebes into the Pacific, is much used from October to December.

The U. S. S. "*Onward*" took this route, leaving Anjer September 24, 1867 for Nagasaki.

Light S.E. winds with frequent squalls from N.W. were experienced through the Java Sea. Sourabaya was passed on the 3rd of October, and Pulo Laut on the 7th; thence to Cape Mandar, light westerly breezes prevailed, with variable winds in Macassar Strait. We entered the Pacific Ocean by the Siao passage on the 20th of October, carrying a moderate N.W. wind with fine weather.

Strong westerly currents were encountered in the Java sea, and a light southerly set in in Macassar Strait.

A remarkable ripple was met near the northern entrance of the strait. The attention of the officer of the deck was attracted by a distant sound to windward, which for the moment he mistook for a heavy puff of wind; looking in the direction from which it came he observed a violent commotion on the surface of the water, the sound increasing as the ripple rapidly approached the ship, the noise was soon heard below, and the whole ship's company rushed on deck anticipating an order to shorten sail, supposing it to be a heavy squall approaching.

Considerable spray was thrown on deck as it passed the ship. The weather was fine at the time with a light breeze and smooth sea.

After entering the Pacific Ocean moderate N.W. winds were carried to lat. 12° 00′ N., long. 136° 00′ E. when the N.E. monsoon was encountered and carried to 28° 00′ N. 125° 00′ E. N.E and N.W. winds were then experienced until our arrival in Nagasaki, November 12th, 49 days from Anjer.

I have referred to this passage as a fair average for a good sailer over this route, from the latter part of September to the middle of November.

It was subsequently ascertained that we would have carried the S.W. monsoon to the northern end of Luzon, had we taken the route up the China sea, which would have shortened the trip by about fifteen days. By taking the Eastern passage we escaped a destructive typhoon which swept over the China sea on the 24th of October, and would, probably, have overtaken us between the Bashee channel and Miac Sima islands.

## Passages to the eastward of Celebes.

The route to the eastward of Celebes is frequented from the middle of December to March, thus escaping the strong northerly winds and adverse currents met with in Macassar strait during those months.

A vessel bound from the Cape of Good Hope at this season would probably select one of the passages to the eastward of Java. If either Baly, Lombok, Allas, or Sapie straits are taken, it would be advisable to enter the Flores sea through Salayer strait, and the Molucca sea by Bouton strait, or along the southern and eastern side of Bouton island, thence to Pitts' passage, keeping well to the northward, as strong southerly currents may be expected.

Having cleared Pitts' passage we have a choice of two routes into the Pacific. Dampier strait is usually preferred from the middle of December to February, when fresh northerly winds prevail; the Gillolo strait during the latter part of February and March, when the winds are light and variable.

In the former case it would be advisable to pass to the eastward of the Pelew islands, when a course may be laid for the Bashee channel, making an allowance of fifteen or twenty miles per day for the monsoon drift.

Leaving Gillolo strait late in the season, it would be safe, with a fair sailing ship, to pass to the westward of the Pelews, and, from about lat. 12° 00′ N., long. 134° 00′ E., lay a course for Bashee channel making an allowance for the monsoon drift as before.

Ombay strait is much used from the middle of December to March, and is considered by many navigators to possess some advantages over other passages east of Java. The route is directly across the Flores sea to Pitts passage, where it intersects the route just described.

### Hong Kong to Singapore in the N. E. Monsoon.

Ships bound from Hong Kong to Singapore, and the straits leading into the Java sea, during the N.E. monsoon, usually take the inner route by the coast of Cochin China until February, and the main route in March and April.

During the strength of the monsoon there is a heavy, turbulent sea, which, by the main route, will be brought nearly abeam, causing a vessel to labor heavily. Deeply ladened ships have been known to receive damages of so serious a nature, from the above cause, that they have foundered before they were able to reach smooth water.

After the strength of the monsoon is over, the main route is preferable; and time has been gained in April by keeping from 100 to 150 miles to the eastward of the main route.

### From Hong Kong to Singapore during the S.W. Monsoon.

The passage from Hong Kong to Singapore during the S.W. mon-

soon is apt to be tedious, but is much easier than a trip to the northward during the N.E. monsoon.

It was formerly considered impracticable to beat down the sea against it, but since the era of Clipper ships the main route has been much used by vessels of that class. A route more to the eastward is much used and may generally be considered preferable; passing Macclesfield bank in about 116° 00′ E. longitude, thence to about lat. 9° 00′ N. and lon. 112° 00′ E. when a southerly course may be taken for the west end of Borneo, following the general coast line to Carimata strait, thence across the Java sea to the strait of Sunda.

The Palawan passage has been used, but seems never to have become a favorite route.

The Eastern passage by the coast of Luzon, Mindoro strait, the Sulu and Celebes seas, strait of Macassar, and the Java sea, is a favorite route for vessels wishing to escape the wear and tear of beating down the open sea.

From Hong Kong to Shanghai during the N.E. Monsoon.

A sailing vessel leaving Hong Kong bound to Shanghai or one of the northern ports during the N.E. monsoon, will generally gain time by standing over, on the port tack, to the vicinity of Luzon; then stand across to the China coast, when she will probably weather Breaker point. The south end of Formosa can then be gained without serious difficulty.

It is the custom with many experienced navigators to beat up along the China coast to Breaker point, and then stand across for Formosa. Both routes have their advocates, and, under certain conditions, each, doubtless, has its advantages.

The latter route might be preferable with a weatherly, quick working ship, and a thorough knowledge of the coast, the probable direction of the winds at different hours of the day, set of tides and currents, and available anchorages.

The route to the eastward of Formosa is almost invariably taken, the advantages being a weatherly current of from 20 to 30 miles per day, instead of an adverse set of 30 to 50 miles in the strait.

The sailing directions usually recommend the route to the eastward in order to escape the heavy seas of Formosa strait. My experience has been that heavier seas are met with on the south and east coasts of Formosa than in the strait, or anywhere else in this region; and steamers avoid the route on that account. The weatherly current above mentioned is its only recommendation.

After passing the north end of Formosa it is advisable to keep well off the coast until up with the Chusan islands, when a course may be laid for port.

Small coasting steamers follow the coast, taking advantage of all passages affording smooth water and anchorages. Large, full powered vessels take a direct route to Breaker point, and then make the lights in succession along the coast.

The most tedious part of the trip is usually from Breaker point to Chapel island. The monsoon seems to attain its greatest force here, with a heavy, confused sea and strong current.

The passage inside the Lamocks, and Brothers, is sometimes taken to avoid the heavy head sea outside.

### From Shanghai to Hong Kong during the N.E. Monsoon.

The passage from Shanghai to Hong Kong during the N.E. monsoon is through Formosa strait, and along the China coast; sighting the lights in succession. Every opportunity should be availed of to get the ship's position, as cloudy, misty weather is the rule, and dense fogs set in frequently when least expected.

The currents are very strong at times, and great caution is necessary in thick weather to prevent running past the port.

### Shanghai to Hong Kong in the S.W. Monsoon.

The route for steamers and sailing vessels is practically the same from Shanghai to Hong Kong in both monsoons.

During the S.W. monsoon sailing vessels usually favor the China coast, making short tacks and taking every opportunity to verify the ship's position, as hazy, foggy weather prevails, particularly in the early part of the season.

The passage to the southward against this monsoon is not as difficult as to the northward against the other. The winds are more variable, and land and sea breezes are frequently met with close in shore.

A moderate sailing ship should make the passage without serious difficulty or delay.

Vessels homeward bound from Shanghai, wishing to escape the wear and tear of beating down the whole length of the China sea, frequently take the eastern passage.

### From Hong Kong to Yokohama in the N.E. Monsoon.

A sailing vessel bound from Hong Kong to Yokohama in the N.E. monsoon would take the Bashee Channel and a direct course from

there to the Gulf of Yedo. Should she fall to the leeward of Bashee channel it would be advisable to take one of those to the southward, not attempting to work to windward until well clear of the islands, where better weather and more sea room will be found. Great caution will be necessary however as this region is but partially known, and imperfectly surveyed.

The route for steamers is the same as that to Shanghai until up with Turnaboat Island: a direct course may then be taken to Van Diemen strait, Oö sima, Rock Island, and the Gulf of Yedo.

Another route, and one I much prefer, is from Turnabout to the Linschoten islands, passing between any of those to the southward of Naka sima; thence direct to Oö sima, Rock Island, and to port.

The latter route has several advantages. The course being more to the eastward, all sail can frequently be carried with the prevailing winds, when fore and aft canvas would hardly stand if steering for Van Diemen strait. The latter place is proverbial for its constant thick, rainy, squally weather, and has been not inaptly termed the Cape Hatteras of Japan.

Clear, pleasant weather is the rule in the Linschoten islands, and the exception in the strait.

The passage through the islands can be taken with safety either by night or day; even in cloudy weather the atmosphere is usually clear enough to distinguish the land at a safe distance. There are no outlying dangers near the route usually taken, and the distinctive features of the islands are so marked that they are not easily mistaken.

I usually steered direct for Suwa sima, an active volcano, which could be distinguished by its smoke and a dense cloud which generally hung over it, before the land was visible. Passing from five to ten miles the northward of Tokara, and from twenty-five to thirty-five miles from Yoko sima, which I never failed to see.

There is an offset from the stream near Van Diemen strait, which, passing through Colnett and Vincennes straits, meets the current through the islands, causing strong eddies and heavy tide rips, and, in my opinion, accounts for the various breakers and rocks supposed to lie off the south end of Tanega sima. I have frequently passed the position assigned them on the charts without seeing anything more formidable than the tide rips above mentioned.

The current of the Japan stream is divided by the islands to the southward of Cape Satano; one branch flowing through Van Diemen strait, the other through the Linschoten islands, the streams joining

again about fifty or seventy-five miles to the eastward of Tanega sima, I have frequently experienced a light counter current in this locality.

There is an average loss of fifteen to twenty miles in current by taking this route, but I consider the advantages of fine weather, a leading wind across the sea, and the simple navigation through the islands, ample compensation for disadvantages arising from the temporary loss of a favorable current, or other causes.

It is usually considered advisable to make Oö sima in passing, to verify the ship's position, as the current of the Japan stream is very uncertain in direction and force.

From the latter point to Rock island, the maximum strength of the stream will be felt. My experience has been from one-half to three knots per hour, depending upon prevailing winds, and other causes not satisfactorily explained.

With the ordinary coast winds a vessel will usually be set a little off shore between the above points. I have never been set inshore except with strong southerly winds.

A steamer will usually make her course good between Rock island and Vries island, but from the latter point to Cape Sagami it will, at times, be seriously affected by the tides, which, at full and change, are very strong, and set on and off shore, across a vessel's track.

On one occasion I found the flood setting into Odawara bay three knots per hour.

### From Hong Kong to Yokohama in the S.W. Monsoon.

The general route for sailing vessels from Hong Kong to Yokohama in the S.W. monsoon is through the Bashee channel, and direct to the Gulf of Yedo.

The route to the eastward of Formosa, and the Linschoten islands, is frequently taken, and even that by the strait of Formosa, and Van Diemen's strait. The latter route is not recommended however, and is seldom taken.

Steamers take about the same route in both monsoons, except that small vessels do not find it necessary to hug the China coast as closely.

### From Yokohama to Hong Kong in the N.E. Monsoon.

Sailing vessels bound from Yokohama to Hong Kong in the N.E. monsoon usually take the direct route to the Bashee channel, thence to port. They would probably find variable winds to about 28° N—where the monsoon should be met with and carried to port.

Steamers, after passing Rock island, usually follow the coast line to Oö sima, avoiding the Japan stream, getting smoother water, and occasionally a light counter current setting to the westward.

From Oö sima a course would be laid for Cape Muroto; thence to Cape Isa, Towi saki, and Van Diemen strait.

In crossing Kii channel a vessel may be set in or out as the current happens to be running.

From Muroto to Cape Isa a steamer will usually make her course good, but from the latter point to Towi saki the set is invariably inshore, except during a N.W. gale.

This indraught has been felt so strong at times that vessels have found themselves inshore to the northward of Cape Cochrane, and, mistaking it for Towi saki, have found themselves in dangerous proximity to Nelly rock.

From Towi saki to Cape Satano it is customary to steer from point to point, avoiding the strength of the stream, and keeping hold of the land as much as possible, for it may be obscured at any moment. I have usually found the vessel set off shore a little between the above points.

Having passed the strait it will be advisable to steer for Kuro Sima, passing a mile to the southward of it, when a direct course may be laid for Tung Ying island, on the China coast, thence to port by the strait of Formosa, before described. The Japan stream is usually avoided by taking the above route.

If a land fall is to be made at night it would be advisable, when approaching the coast, to make Turnabout light. It can be seen twenty-four miles in clear weather, and I have never failed to see it at a distance of eight or ten miles.

In making the land in this vicinity I have usually found the ship to the northward of her course, and never to the southward, even with strong northerly winds.

The length of this paper admonishes me of the necessity of bringing it to a close. I wish to observe in conclusion, that it does not aspire to the dignity of a sailing direction, an object unattainable in a paper of this kind.

The subject covers so much ground that I have found it impracticable to enter into detail in any of its various branches, simply glancing at the physical geography of the region embraced in the title, as affecting the navigation of its waters.

I have attempted to draw attention briefly to most if not all the

routes experience has taught us to adopt under the ever varying conditions of wind and weather.

The periodical and prevailing winds, and other atmospheric phenomena, occupy a large portion of this paper, as having the most direct and important bearing on the subject under consideration.

The various currents materially affecting navigation have been briefly noticed.

The meteorology of the region embraced in the title, furnishes material for a most interesting and useful paper; and it is to be hoped that some of our officers whose duties have peculiarly fitted them for the discussion of this subject, will favor us with the result of their investigations.

Those who are familiar with the standard authorities on the China sea, are aware of the fact that much of the data dates far back into the eighteenth century, supplemented from time to time, in new editions, with more recent information ; the several volumes of the present day being a compendium of personal experiences.

If my experience related in this paper has added anything, however insignificant, to the general knowledge of those distant and imperfectly known waters, or if my efforts shall induce others, more competent, to take the subject up, in any of its branches, the object of this paper will have been accomplished.

Lieut. Collins. I would like to ask what the action of the barometer was previous to and during the cyclone alluded to as having occurred to the northward of Madagascar.

Lieut. Tanner. I have no data at hand, and do not recollect the exact height, but I remember its general action perfectly well.

When it fell calm on the morning previous to the storm the barometer was at its normal height in good weather, something over 30.00 inches. It began to rise rapidly during the morning and, at 4 P. M. was unusually high, showing a decidedly abnormal atmospheric condition. It then commenced falling, slowly at first, then rapidly, until 8 P. M. The Captain was then convinced of the near approach of a cyclone and commenced his preparations to meet it.

The greatest depression was at about noon, when the storm was at its height, it was between 27.50 and 28.00 inches. It began to rise between 1 and 2 P. M., the wind moderating during the afternoon.

As the subject of this gale has been brought up it may not be out of place for me to mention some of its features.

The close reefed top-sails and storm stay-sail were blown away about 6 A. M. The hands had been called to take them in, but the wind increased so rapidly there was so chance to save them.

From 9 A. M. to meridian the lee scuppers were under water most of the time, the sea a mass of seething foam, with a dense white mist enveloping the ship to the height of the tops. A tropical sun was shining brightly over head, and the evaporation was so rapid that the wood work on deck, the ships' sides, masts, and rigging, were soon covered with a coating of salt, our faces, hands, and clothing were covered with it, the air was full of it, we could see it, taste it! The foam and mist was so dense that blue water was not seen for several hours.

We had marled the sails to the yards with studding-sail gear, but they were eaten away between the turns, and those that were not entirely blown away required extensive repairs.

After the topsails blew away we lashed some new tarpaulins in the weather mizzen rigging, but they blew away during the forenoon. There was but little sea until the wind began to moderate during the afternoon, then we had a fearful one, knocking the ship about so badly that seams and butts opened in the most alarming manner.

The ship was cotton loaded and, as far as her cargo was concerned, met the gale under the most favorable auspices.

Lieut.-Comd'r. Nelson. Although not within the limits of the paper, I would like to ask Lieut. Tanner if the mail steamers between San Francisco and Yokohama take the Great Circle route, and if not, for what reason.

Lieut. Tanner. The Great Circle is never taken by the side-wheel steamers. The propellers take it at times during the months of June, July, and August. An approximate Great Circle is usually preferred however.

Westerly winds prevail to such an extent over the northern part of the Pacific ocean for nine months of the year that a constant swell may be expected from that direction. Winds and sea are generally heavier as the higher latitudes are approached, decreasing in the region of the trades.

In crossing on rhumb the line it is nothing unusual to encounter a heavy N.W. swell for a week or ten days at a time with little or no wind, not enough to steady the ship with sail. A constant heavy rolling must be submitted to or the ship hauled up head to sea.

This swell is as much, if not more, dreaded than the gales on this route. To avoid it as much as possible the side-wheel steamers adopted the route

from San Francisco to thirty degrees N. one hundred and forty degrees W. crossing on the thirtieth parallel to one hundred and fifty degrees E. thence to port, making the distance five thousand two hundred and fifty miles.

Returning they usually take the rhumb line, the distance being four thousand, seven hundred and seventy-seven miles.

In making the trip to the westward in the "City of Peking" I usually took the rhumb line, but if heavy westerly or N.W. winds were encountered, would bear away to the southward and westward under steam and sail, for the side-wheel route, or until milder weather was found.

I usually took the great Circle in returning, to about forty degrees N. during the winter months; forty-two to forty-four degrees N. during the autumn and spring, and from forty-four degrees to forty-six degrees N. during the summer, making the distance four thousand six hundred to four thousand six hundred and thirty miles, the great Circle being four thousand five hundred and twenty-three miles.

The latter route would take a vessel to forty-eight degrees, twenty-five minutes N. and in the winter time it would be so cold that the sails and running rigging would be frozen at times, making it impossible to gain the full benefit of fair winds

Crossing on the parallel of forty degrees N. better weather is met than nearer the islands, and it is never cold enough to freeze much—not enough to interfere with the handling of sails.

Constant fogs will be encountered on the great circle route during the summer, and as they are not as frequent between the parallels of forty-four degrees and forty-six degrees N. that route is usually preferred. Much misty weather will be found all over the North Pacific in the summer, but on the latter route the sun will usually be seen during the day, and stars at night, a heavy mist hanging over the water.

When the Occidental and Oriental steam ship line commenced running they adopted the great circle route but the wear and tear was so great, that after a year's experience they abandoned it except during the summer months.

Rear-Admiral Jenkins made some general remarks on the relative value of side-wheel steamers and propellers for Ocean service, and the route between San Francisco and Yokohama in particular.

In referring to the typhoons of the China sea he said that when he took command of the Asiatic station he gave orders that no ship should go to sea with a falling barometer. The result was that during the two years he was in command he never had a vessel caught in a typhoon at sea. He thought with proper caution a man of sense need seldom be caught in a typhoon at sea in time of peace. In war time it would be different, it might be necessary to take extra risks then.

TRACK CHART OF THE CHINA SEA AND APPROACHES.
100° E
110°
120°
130°
140°E.
40° N.
30°
20°
10°
0°
10° S.
CHINA
SEA OF JAPAN
KOREA
NIPON
JAPAN
WHANG HAI YELLOW SEA
PEKING
NANKING
CANTON
FORMOSA
HAINAN
SIAM
CHINA SEA
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# THE RECORD

OF THE

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Commodore FOXHALL A. PARKER (Vice President), in the Chair.

## ON THE EMPLOYMENT OF BOAT GUNS AS LIGHT ARTILLERY FOR LANDING PARTIES.

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At the risk of being accused of devoting too much attention to what is termed, by some officers, soldiering, I would ask your attention this evening to a few remarks in reference to our possible operations on shore.

The Naval Brigade is not a new invention. As long as navies have existed the crews of ships have been, from time to time, employed as troops. We can hardly read ten consecutive pages of the naval history of any nation without coming across the descriptions of the doings of seamen on shore, either alone or in conjunction with the regular land forces. Some of these operations have been successful, others have been wretched failures. It is interesting to note however that the greatest successes have followed the most intelligent preparations. When we are in Rome we must do as the Romans do. When we go ashore to fight we must fight as they do on shore. It seems ridiculous to suppose that we could gain any advantage, except over the untutored savage, if we do not profit by the teachings of those who by experience and study have made themselves the mentors of our sister service. A few years ago, in an official document, a high officer of the army said that a merchant steamer armed with guns and manned by artillerymen would be a complete substitute for a man-of-war. This idea was scouted at in the navy. Would the idea of calling away the starboard watch and going ashore to board a fort, seem any less preposterous to our gallant friends in the army? If we are to go ashore to fight we must for the time being forget entirely that we are sailors. We must

have thorough army organization, equipment and discipline; and follow out received principles of manœuvring in order to be able to accomplish anything. If we cannot do this we had better never leave our boats.

The untutored savage is becoming a greater rarity every day. No better proof of this fact is necessary than that of the number of the most improved fire-arms which are being exported from our country to every part of the globe. The Zulu is better armed than the Englishman, the Indian than the American. The papers are talking of a coalition between England and Russia to restrain the growing military power of China.

It seems absolutely necessary, however, from the role which our men-of-war have to play, in protecting the lives and property of our own citizens, and those of friendly nations, even in time of peace, that we should sometimes go where the guns of our ships cannot reach, or where, if they did reach, they would do as much harm to friends as to foes. In order to do this we must make our officers and men efficient infantry and artillerymen. There was an old idea that a sailor could not be made efficient as any thing but a sailor. This idea, thanks to our gallant President and Vice-President, as well as to many other intelligent modern officers, is fast wearing away. Some of the drill hours in port can easily be devoted to acquiring something of this knowledge, instead of wearing out our spars, sails and rigging, to say nothing of our good sense, in exercises which are of no real service at sea. In order to gain the proper information the ceremonies of review and dress parade should be rigidly tabooed. In how many ships is any thing in the way of battalion or naval brigade drill attempted? all the time devoted to this branch being consumed by these useless mummeries. An inspection with opened ranks and a passing salute is all that discipline or efficiency really requires. What we want to do is to make our men real working soldiers and marksmen. The study of the whole system of the Naval Brigade would be exceedingly interesting, but our time and space preclude it. We shall find enough in the subject of our thesis for one lecture and shall hope that another officer, who is with us this evening, and who has devoted much time and intelligent study to the subject, will tell us something, on a future occasion, in regard to the infantry branch.

An eminent naval officer once told the lecturer that he did not believe in "hard and fast" rules in regard to landing parties. We probably all agree with him. We must however have some system,

and that system must be capable of modification to suit circumstances, and must be calculated to cope with the most intelligent and best armed enemy; what will do for him will carry us through with the unintelligent.

The cases under which we would land boat guns would be:

1. To occupy a seaport town or buildings in that town; as at Montevideo, Panama and Honolulu.

2. To attack inland ports; as in the Corea.

3. To make a raid into the country in conjunction with the Naval Brigade; as on the James river.

4. To accompany the army when they could not land or had not their own artillery; as in North Carolina.

5. To make a long march inland; as in the Ashantee expedition.

Generally speaking the number of guns which we land is out of all proportion to the number of men. The generally accepted number, in all modern armies, is two to a thousand men. We far exceed this number. Our ratio at the Key West landing was eighteen pieces to about two thousand men. Under certain circumstances, as for instance, in the first case mentioned, this might be permissible, but would it be safe to so far exceed the general rule for manœuvring? Would it not be better to reduce the number of pieces and increase the crews and amount of ammunition, even if we had to convert some of our gun carriages into caissons. Four pieces to a thousand infantry would seem to be the utmost limit which we could safely reach, with any hope of effectiveness, for field operations. We must remember that these pieces have to be dragged and defended. When we consider that one good repeater in the hands of an expert marksman, under certain circumstances, will do as much and even more execution than a piece, should we weaken our infantry strength?

Col. Brackenbury, himself an artilleryman and an authority, after citing the disastrous effect on gunners by infantry marksmen at Okehampton, says: "Here we have to face the great question of the comparative physical and moral power of infantry and artillery, and the moral effect produced upon one or the other arm by equal losses."

Before attacking this subject, permit me to say, that, in my humble opinion, the principal arm, the mainstay of an army, is as it has been, and must be long after our time, the infantry. It is the easiest trained, the cheapest to place in the field and to keep there, the only arm which is equally powerful at rest and in motion, the most easily concealed and the simplest in its armament and use. Only infantry can

decide battles and secure the ground won. Whatever may be the increasing value of artillery, it can never supply the place of a single infantry soldier. But on the other hand the value of artillery has grown greatly of late years. If the guns are of no use when in motion, their long range renders the necessity of their motion much less.

Artillery can be sorely annoyed or even caused to retire by the fire of infantry skirmishers well concealed in folds of the ground or behind walls and trees. Therefore infantry should not attack in any formation, but, so to say, stalk the guns. And this being granted infantry should always attack guns; who knows but what they may be *unsupported?* The only reply to such hidden attacks when there is no *attached support,* is by the use of dismounted cavalry, or, better still, by dismounted men trained to work on foot either as *riflemen or gunners and permanently attached to the batteries.*

In small landing parties, the number is still more disproportionate; the writer has seen a gun landed with an infantry force scarcely larger than its own crew, a large part of which was comprised in a color guard. This imposing force would probably bring a smile to the face of an old campaigner. If the proportion which we have assumed should be adhered to, a gun would never be landed with less than five good companies of infantry, on the supposition that these companies will be about forty men strong.

Guns, when landed for field service, should be accompanied by an extra carriage, fully manned, which should be fitted and used as a limber. This, if the two crews were full, would give a double crew of forty men. For service near the base of supplies, or for position batteries, as many guns as possible might be landed; the extra ammunition being stored in temporary magazines or in the boats. It should be borne in mind that a gun is only effective while it is thoroughly supplied with ammunition.

In this arrangement we have allowed twenty men to a crew. This is the least number that can be expected to render a gun thoroughly mobile under ordinary circumstances; on a long march or over very bad ground this number would have to be considerably augmented; as many as fifty men have been employed in some cases on record. The extra carriage arrangement gives, besides the extra ammunition, with so much extra weight it is true, nearly this number, and greatly increases the ease of motion of the piece by raising the trail off of, and sometimes literally out of the ground. The trail of the extra carriage, which we would designate as the limber, should be fitted like

that of the long Gatling gun, with handles and a supporting rest.

There has been a prejudice amongst many commanding and executive officers against having limbers aboard ship. Our plan would not bring any extra gear, as most ships have already two guns mounted on field carriages, and as, if our proposition was accepted, only a few of the guns would be landed.

Even with the large crew proposed, extra men may have to be borrowed from the infantry on the march; or it may even become necessary to relieve the whole of the motive-power part of the crew by infantry. We use the words "motive-power part of the crew" advisedly, as we would divide the crew under two heads,—the cannoneers and the dragmen or riflemen.

In action any of our pieces may be fully served and supplied with ammunition by at most eight men and a quarter gunner; this number exceeds that allowed at the largest army field guns by two, and is more than should be allowed about a piece, in order not to offer any larger target than absolutely necessary to the enemy's fire. This number of men can also move the pieces and ammunition boxes, for small distances, without assistance. We would designate these men therefore, as the cannoneers. They should never leave their piece and should be taught to rely entirely upon it for offensive and defensive purposes. In order the more thoroughly to inculcate and insure this, these men should have no firearms, and should only be supplied with battle axes and intrenching knives. These would be of service in repairing carriages, cutting away obstructions, intrenching etc, and in case of a hand to hand mêlée would be quite as serviceable as a cutlass.

General Gibbon says: "Let the rifles be given to the infantry, and the sabers and revolvers to the cavalry; *guard the artillery with these arms,* and teach them that their salvation is in sticking to their pieces."

The cannoneers with the exception of numbers seven and eight are generally stationed, on the march, at the guide and short drag-ropes, and the wheels. Their labor is therefore comparatively light, and as they have no small arms or small arm ammunition, they might be expected to carry a couple of complete rounds apiece for the gun. The quarter-gunner would have his haversack containing spare articles, tools, primers, fuzes, etc. The remaining twelve men, whose only duty, in connection with the moving or working of the piece, is in long changes of base or on the march, in other words the drag-men who replace the horses in an army battery, we would arm and designate as riflemen for reasons which we hope to make clear further on. As they only re-

quire enough small arm ammunition to defend the piece when actually attacked, and are not expected to take part in the general manœuvres as infantry, they each could carry a passing box containing two cartridges for the piece, the projectiles being carried in the axle boxes. These are now generally fitted to carry, in all, twenty rounds, but by this arrangement might be increased to hold thirty-two. This would give a total of forty-eight rounds per piece with a single crew, and one hundred and six with a double one and limber. This is about the number allowed to a field piece in the army for field service. Two thirds of the projectiles should be shrapnel, and six rounds of canister per piece should be carried, according to the best authorities.

The cannoneers of the limber crew should be equipped similarly to those of the piece. In case of casualties they would replace their corresponding numbers at the gun, otherwise they would manœuvre the limber, and take charge of the ammunition, keeping themselves and their charge well under cover in reserve. A word as to the position of this cover. It is generally the custom to place the ammunition from twenty to twenty-five paces in rear of the pieces when in battery at exercise; as in all drill formations in order to secure uniformity it is necessary to give certain distances. This distance must not be blindly adhered to in the field nor always at drill; the distances might be greatly increased in order to get good cover, the charges being passed up if necessary by a chain of men; nor is it absolutely necessary to place the ammunition in rear of the pieces which under some circumstances of artillery fire would be the most exposed position. A good cover on the flanks should be selected in preference, giving the double security of protection and removal from line with the troops. The windward side of the line of guns is preferable to the leeward unless it should be found that most of the enemy's projectiles deviated in that direction.

The dragmen should be armed with the most perfect weapon possible, which today would seem to be the repeating rifle. They should not be provided with bayonets as they will not be required to charge, but should have a good intrenching tool. They should not carry as much small arm ammunition as a regular infantry man, as they will only be required to protect the battery. In compensation for the possible difference of weight between the bayonet and intrenching tool, and the small amount of small-arm ammunition, they should carry two cartridges for their pieces.

All modern writers on artillery seem to coincide in the opinion that,

to make artillery at all effective when closely engaged, it must be supplied with a permanent support. In army batteries under most circumstances a support could readily be detailed from the large number of infantry generally at hand. In the Naval Brigade, where every man counts, after taking the large number of men already detailed for our guns, it would hardly be prudent to still more reduce our active strength by detailing men for permanent supports, on the march or in action, especially when, in a single crew, we could have twelve men who would be utterly useless while the piece was in action. There is nothing that we can give them to do. The best troops in the world, without effective arms and occupation under a galling fire, would seek shelter, and this shelter might be found *so very far to the rear* that when it really became necessary to use them to move the piece, they might not be forthcoming. As we cannot place our blue-jackets quite on a par with the best troops, much as we would like to, we must give them something to do and make them useful.

We have already quoted what Col. Brackenbury says about permanent supports.

The Commission on the reorganization of the French Artillery report: "Many officers think that the troops employed as temporary supports for artillery do not perfectly assure its security, and propose to create particular troops to form permanent escorts to the batteries."

Archduke John of Austria, says: "That artillery should be self supporting; that it should have with it its own supports; that with an open front it can protect itself against advancing infantry with its canister, and shrapnel with fuses cut so as to explode at the muzzle; but with an undulating front or one with cover for skirmishers it is perfectly helpless." In consequence of this opinion, coming from the highest authority on the use of light artillery in Austria, there has been permanently attached to each battery, three non-commissioned officers and twenty-four privates whose duty it is to act as riflemen. They guard the battery on the march and in camp. In action they replace the cannoneers in case of casualties and protect them from the attacks of skirmishers. The writer saw numberless batteries thus equipped, moving into Bothnia last summer. He also noticed at the manœuvres at Aldershott and the Autumn manœuvres in France, that all the limber and caisson boxes have rifles strapped to them for use against skirmishers. Can we do less?

The range of artillery has been so greatly increased that the whole system of artillery fighting has been changed. Where Napoleon, and

Scott even, pushed their batteries up into the first line, within stone's throw of the enemy, we would, except in a great emergency, place our guns in a commanding position, which, after we had once picked up the ranges, we would try to maintain. The modern rifle is most effective when coolly handled, properly served, and when the ranges are accurately known. The ricochet of the old smooth bore has ceased to be a factor in the problem of hitting.

There seems to be no doubt that a field gun must be a rifle, on account of its long range, accuracy, flatness of trajectory and consequent increase of the danger space, and that to obtain the best results a rifle must be a breech loader. Some naval officers seem to cling to the old smooth bore Dahlgrens as boat guns. Why, they can hardly tell themselves. They advocate the rifle for the ship and the rifle for the man, but stick to the smooth bore for the boat and for the battery. It is unquestionable that the old smooth bore could stand more hard usage than the perfected-breech loading rifle, but is not the same true as between the old sea-dog and the modern educated seaman, the blunderbuss and the repeating rifle. The true reason probably is that canister was so effective from the old gun in the hand-to-hand fighting, of which we are *told*. Canister can be used just as effectively with the rifle in an emergency and should be supplied in small quantities for such occasions. The breech loader it is true requires more care and more careful and intelligent handling, but so does almost every contrivance used afloat. A want of knowledge of the working of a machine often causes it to be rejected in the popular mind as useless. Two years ago, an officer, who had had for some time under his immediate command two Gatling guns, asked the writer to tell him how to get out a lock. A few days before he had been on active service with them ; had a break down or a stoppage occurred in action, he would probably have attributed it to the complication of the mechanism.

In regard to the employment of machine guns on shore, it would seem that one must be entirely guided by circumstances. The Gatling would be of great service in defending approaches or in street fighting where the enemy kept to the streets and did not fight from houses, barricades or behind cotton or hay bales. It is very doubtful however, whether one would be as useful as twenty men (its crew) armed with repeaters, under any circumstances. It certainly would not replace a three inch B.L.R. in the field. The Hotchkiss revolving cannon, if adopted, with its explosive projectile, of lawful dimensions, its long

range, and great facility of pointing and training, might be of great service under almost all possible circumstances.

At the present moment the steel three inch B.L.R. is the most effective field piece which we possess in the navy, and it should always be given the preference for field service.

In order to make artillery fire thoroughly effective, there must be some way of ascertaining the correct range. A few hundred yards out, in a range of three thousand yards, would seem little, but reduce the range to three hundred yards and see what it would be. The same effect is produced at the longer range. The fire must be accurate to be of any use. Artillery seems to be under a cloud in Europe on account of the small results in comparison to the number of guns employed and amount of ammunition expended in modern wars. This is entirely due to a want of knowledge of the distance from the target.

The "Instructions sur le Service de l'artillerie" approved by the French Minister of war, April 20th, 1876, gives the following interesting list of means for determining distances:

" Distances in the field can be found by divers methods;

1st. Practiced eye sight.
2nd. Topographical Maps.
3d. Special Instruments.
4th. By the interval between the flash and sound."

1. By continued practice the eye can be relied upon up to five hundred yards. Beyond that distance the variable condition of the atmosphere and the lay of the ground cause large errors.

The following hints may assist when other means are not at hand:

With ordinary eye sight are visible, at

30 yards, whites of eyes;
80 yards, eyes;
150 yards, buttons;
300 yards, faces and principal parts of uniform;
500 yards, head;
800 yards, movements of arms and legs;
1200 yards, outline of men and horses;
2000 yards, horses and men;
4000 yards, the number of windows in a house.

A good glass will greatly assist the operator but he should have determined its relative points of visibility which should be printed on a small piece of paper and glued on to it for reference.

2nd. If a chart or an accurate large scale map is at hand, the dis-

tances may be ascertained by noting the proximity of permanent landmarks such as houses, cross roads, prominent trees &c. By plotting these an approximate distance may be obtained.

3d. We have none of the instruments in service which would render this method effective. In Europe very excellent results have been obtained with several systems of range finders, especially that of our countryman Col. Berdan. Range finders would be very valuable to us for all kinds of firing and it is to be hoped that the Bureau of Ordnance will be able to get the necessary funds to provide at least one to every ship.

4th. By the interval between the flash and the sound of the enemy's arms. This can be done when the flash and its corresponding sound can be sharply distinguished, by means of a good ordnance watch, or by Boulange's Telemeter. This method is however useless in the confused din of battle.

In the field, shrapnel will generally be found the most effective projectile at almost all ranges. In picking up a long range it will generally be best to use first a few shell, as their explosion is more readily observed. At very short ranges canister will be found most effective, as no time need be lost in cutting or setting fuzes. The moral effect of the explosion of the projectile will however be lost.

A good position once taken up should not be abandoned without a very good reason. A few hundred yards difference in the position of a rifled piece of long range would make very little difference in the effect of the fire. In a successful attack guns should not be moved to the front for distances less than five hundred yards, and then only to take up a very much better position. The distance moved should be accurately noted and corresponding changes made in sights and fuzes. It must be borne in mind that, while a battery is being moved, and even for some time after it has taken up its new position, it is non effective.

Major Hoffbauer, the German artillery authority, says: "Changes of artillery position are rendered necessary by the course of the combat, but if frequent they are detrimental and, if a few hundred yards only, are to be avoided, unless it is necessary to make a short movement to the front or rear in consequence of the enemy's having got the range too accurately, and so mislead him or cause him to get the range afresh." Again he says: "When a battery ceases fire from want of ammunition it remains in position as it thereby deceives the enemy, who, not knowing the cause, expects it to reopen at any minute."

Artillery fire will generally be carried on at long range; the circum-

stances where guns would be opposed to guns at short range would be almost unprecedented in modern warfare. The side having the lightest guns must get close enough to the enemy to neutralize the effect of his superiority in this respect.

Against infantry deployed as skirmishers it would be best to turn the guns on the reserves and let the supports attend to the skirmishers. An effective skirmish line is acknowledged by all professional artillerymen to be the most deadly enemy with which they have to contend.

At the battle of Vionville the 2nd Horse Artillery battery of the 3d Army Corps was forced to retire before infantry skirmishers, when the skirmishers had succeeded in approaching to within from twelve hundred to fourteen hundred paces from the guns.

At the battle of Noissiville there were sixty German guns drawn up on a tongue of land running down from Poix and Sevigny towards Metz. The French infantry came down and before them the sixty guns had to retire.

At the same place four Prussian batteries had taken up position on a hill near Vionville; the French now advanced with swarms of skirmishers, reoccupied Vionville and pushed through the village against the guns. The two batteries closest to the village, having no friendly infantry near them, were forced to draw back under cover of the hill; but Müller's battery—one of those which had come forward from the infantry division and was not far off—moved up close to the village and came into action under a heavy fire, several horses being killed and wounded. Swarms of skirmishers again rushed out of Vionville and the moment became critical. The guns were finally forced to retire. As all these cases are taken from German sources they are certainly not exaggerated.

Unless shrapnel can be exploded in exactly the right position, against skirmishers it is no more effective than a single rifle bullet. It can only injure one man at the most. As a single man killer the most accurate field piece is far inferior to a rifle in the hands of a good marksman. And when we consider that we have reliable information that the Turkish (American) rifles at Loftcha and Plevna were effective up to two thousand yards, we can see that even for range against human targets at that distance the rifle is its equal. It takes longer to load, it is harder to point, especially on a movable target and offers, with its group of cannoneers out of shelter, a far larger target. Riflemen must be opposed to riflemen. It is at this point that our drag-men armed with rifles will be of great service, firing from either between

the pieces or on the flanks of the battery. The guns would be used against the reserves which, in all modern tactics, are formed in columns so that they can be deployed quickly. These reserves follow the skirmish line and supports at distances varying from four hundred to one thousand yards. In the German tactics no group formation is allowed at distances under eight hundred yards from the enemy. The artillerists will endeavor to demoralize the reserves by their fire, they being the more easily affected from the mere fact that they cannot return the fire. The reserves being demoralized, the skirmish line must halt or fall back. This is the only effective way in which artillery can repulse an infantry attack. Infantry in marching order advances in double time for short distances one hundred yards a minute.

Long range firing must be very deliberate in order to insure accuracy in pointing and to save ammunition. Not more than a shot per minute can be fired with any accuracy. At this rate, even our maximum supply of ammunition would only last about two hours. The largest target should always be selected. Even at twelve hundred yards the head of a column of fours, which is less in breadth than one of our regulation great gun targets from lower corner to lower corner, does not offer a very good mark. It is for this reason that distant bodies of the enemy are kept in column; the chances of error in range being greater than those in a horizontal direction, the nearer approach or skirmish line is reduced to a single line, widely spaced, which we can imagine as so many small columns one man wide and one man deep. Even this mark is reduced nearly one half by the man's kneeling and to almost nothing by his lying down. Skirmishers are also instructed to take cover which still more decreases our chance of hitting unless we can pierce or destroy the cover.

Let us examine the probable circumstances of landing and the actual employment of the pieces on shore.

The Naval Brigade should never be landed unless it has a fair chance of success. The consequences to a ship or squadron, if deprived of the number of men generally landed, by defeat or capture, would be disastrous in the extreme. When the work can be done from behind the ship's regular battery it should always be preferred. The range of our great guns is very long and the effect of the projectiles very great. The threat of a bombardment or its actual fulfilment would be far more salutary, in most cases, than the landing of, at best, a numerically weak body of troops.

Where the ship's guns cannot reach, the boat guns may and we are

still on our own element. For this reason larger guns than can be handled as field-pieces should be provided for those boats, or *gun-rafts*, that can carry them.

When we must land we must take all human precautions for our success. The landing should be carried on if possible under the ship's guns. If this cannot be it should be covered by the light vessels, seized or chartered and armed, if necessary; and as a last recourse by the boats and *rafts* carrying heavy guns. The artillery should be the last to go ashore. The guns while in the boats are effective for protecting the landing and advance for some distance, annoying the enemy and forcing him to keep under cover, and covering an immediate repulse. The artillery boats should be placed on the flanks in landing on a long beach, so that they can cross their fire in front of the landing party. When landing at city wharves the artillery boats should be collected and held some distance off from the landing, in order that their fire may be effective against surrounding streets and buildings and not masked by the wharves and shipping. In this latter case it would be well to push the Gatlings ahead as they could be used in sweeping the streets leading from the landing.

The infantry being ashore and well established, such of the guns as are to be landed should be gotten ashore as quickly as possible. The remaining gun-boats should be placed in such positions as would most readily command the approaches to the landing place.

For landing in a town these boats should be stationed at the foot of streets running parallel to those by which the advance is to be made; this would, in a measure, guard against flank attacks.

While we are on the subject of landing it will be well to mention that in many cases a good cask raft, or large Rider bolsa raft, will be found better than a boat as a gun platform, especially if a hammock breastwork is formed around its edge. This would be particularly useful in landing in shoal water.

As we have two cases to treat let us first take that of the town.

We may land in a town to protect or hold the whole town against an outside enemy or merely to protect certain buildings. To protect the town the chief of artillery, in conjunction with the commanding officer and his staff, would select such positions, on the lines of defense, as would make his guns most effective; notably those commanding the approaches, and those giving a raking or flank fire down the lines of defense. Where a strong defense was intended it might be necessary to land the larger boat guns and even some of the ship's battery. A

second and even a third line should also be arranged in case of a successful assault and a citadel selected for final defense.

The guns in position should be protected by breast works or barricades. In this connection it would be well to remember the great efficiency of baled goods for breastworks or for advancing under fire. A cotton bale rolled before a few men enables them to resist almost any kind of fire. Magazines should be established near the guns. The ranges of surrounding points should be thoroughly determined and marked down, these points should be named and the men drilled in pointing at them. The definite naming of points by a commanding officer will greatly facilitate the direction of fire. Flank traverses should be built to prevent the guns from being enfiladed.

To protect single buildings they should be treated in the same way on a smaller scale. Pieces on the roof will be found useful in shelling surrounding buildings which might be occupied by the enemy.

The landing made to operate in the country, is our second case. When acting with the army, which is supposed to be without its own artillery, the whole energy of the naval force should be devoted to properly supplying that want. An extra number of men should be detailed for the pieces and extra limbers taken if necessary so as to increase the amount of ammunition. Carts must also be impressed for this purpose if possible. A goodly number of pioneers should also be detailed.

When acting by ourselves we must furnish as large a force of riflemen as possible with a proper proportion of artillery.

Once ashore and intending to move into the interior, a portion of the artillery should be posted near the head of the column the other near the rear. It should never take the extreme front or rear. When there is a large force some should be stationed in the center to be in position in case of a flank attack.

It is the role of the artillery to open a regular battle. This battle may be engaged on any side of a column. We should therefore place our guns so that no matter on which side the blow comes we may have a first line and a reserve. The chief of artillery should always accompany the commander in chief, as their actions must be concerted.

Should the column be attacked on the march, the artillery on the side of the attack should go in battery as soon as possible and open fire. The pieces in reserve should be moved to the best position that can be found in the vicinity. These latter in position, and having

opened fire, the advanced pieces should be moved to them or placed in other good positions.

Before entering woods likely to be occupied by the enemy they must be shelled. Should the column attack the enemy, the chief of artillery would first move out with the first line and select the position to be occupied by his battery or batteries. These should be concentrated as much as possible.

In regard to position the main consideration is an extended and open range, such that the ground can be swept at the shortest distances. Other desirable conditions are sufficient space, a level surface, wide command and that the position be perpendicular to the line of fire and not too irregular in its general outline. The most favorable positions are behind the crests of ridges or undulations which slope gently towards the enemy; or else in rear of low eminences, hedges and such like. Stone walls are to be avoided except when engaged with infantry alone. It is not however advantageous to post guns *immediately* behind cover or close to conspicuous objects as they facilitate the enemy's range.

Some authors claim that the guns should be on the flanks of the line, as they then would get a better chance to get a flanking fire at the enemy, which is always the most effective. The objection given to this is the too great exposure of the guns to being cut off. Others claim that the best position is in rear of the main line, on the ground that it gives a greater latitude in selecting a position, and improves the morale of the infantry. As good authorities are to be found for both principles, the probability is that the artillery officer had better be guided by circumstances and select the most commanding positions to be found in reference to the proposed infantry movements. Care should however be taken not to select a position which may be overtopped or commanded by the enemy.

Advantage should be taken of irregularities in the ground to protect the pieces and ammunition without regard to alignments or distances. A rise of from two to two and a half feet in front of a piece sometimes protects it entirely from the enemy's fire. The ground in front should be clear and destitute of cover for the enemy's skirmishers. A position just behind the crest of a ridge is excellent, as the shot which strike the summit will bound over the battery and those which strike below will of course not reach it. It also baffles the enemy by not allowing him to see where his shot strike over. Care should be taken in the event of an assault, that, by moving the pieces on to the

crest, they can command the approach, or otherwise the enemy might gain cover.

Artillery should not be placed on rocky soil in consequence of the hard surface it affords for percussion projectiles, whose effect would be increased by the splinters and gravel. Slippery or marshy ground, except as a front or flank defense when on the defensive, is also to be avoided; also ground much cut up by ditches, fences, and other obstructions which would render it difficult to move the pieces. Of course the main object will be to select a position which commands that of the enemy and the approaches to our own.

The position having been selected, its front and flanks thoroughly explored by a detail of riflemen from the pieces, acting as skirmishers, which could be done, as the guns would be halted to the rear, or moving up slowly, and their absence not felt; the commander would order his pieces into position and, having ascertained the ranges, would at the proper moment open a very slow fire, which he would personally superintend, increasing or decreasing the rapidity, and changing the target to meet the movements of the enemy.

In case of a considerable advance of our line, making the selected position no longer the best, he would move to the front and select a new position to which he would move his guns. The change should be markedly for the better, however, to compensate for the loss of time and accuracy.

In case our line is repulsed and the enemy is advancing his skirmish line, or in case we are acting on the defensive and being attacked, he would hold his position until the last moment if he saw any chance of success or wished to save the infantry. The fire of the guns would be directed at the masses of the enemy and as they deployed and reinforced the fighting line he would change to it. The riflemen of the battery taking post on the flank or in the line, would devote themselves to picking off the enemy and protecting the cannoneers. Should the enemy assault the battery, canister and the magazines of the repeating rifles would be called into play.

In case a general retreat is ordered the commander would select positions, to the rear, to which he would move his pieces by detachments, holding the ground as long as possible.

In case of the inevitable capture of the pieces, they should be destroyed or at least temporarily injured. This is easily done with the breech loader by removing the plug. The carriages should also be dismounted and otherwise injured, the important smaller parts being car-

ried off, and the ammunition destroyed. This is done in order to prevent the enemy from turning the guns on our own men.

In order to carry out all the movements required by a battery in the field at the present day but few manœuvres are required. Pieces must never be engaged at close quarters except as a last resort. The greatest attention should be paid to marksmanship and handling of the pieces. How many boat guns are now landed in our service for drill, and sometimes even for actual service, which the crews have never fired nor even seen fired! Would a well drilled or even an indifferent man-of-war's crew be much appalled by the approach of a vessel manned and officered by even the most intelligent landsmen if they had not been drilled? And yet we expect to go ashore and without study or drill transform ourselves into soldiers. Soldiers we must be, when we go ashore, in order to be anything more than an armed mob. This is a matter that must be taken in hand by the highest authorities, and not left to the volition or intelligence of commanding and executive officers. England, France and the other first class naval powers have come to this decision; so must we. Much harm is done by some of us in confining our shore drills to mere empty show. This should be rigidly forbidden and an intelligent organization prescribed, simple movements taught, the greatest stress being laid on modern fighting movements and skirmishing. Marksmanship is of course of the greatest possible importance, and should be required and encouraged in all. This point is alike important to the blue jacket whether acting as sailor or soldier. In order to encourage this feature, the dead letter regulation in regard to the giving of prizes, should be rigidly enforced. Let us take for a principle that "What is worth doing at all is worth doing well."

Commd'r MAHAN. The lecturer proposes to arm the dragmen with rifles, preferably magazine guns, also to have them carry a passing box with two pounds of powder, small arm ammunition and an intrenching tool. In addition to these there are things which he has not mentioned, but which we all know must be carried, such as provisions, an overcoat, blanket &c. Now the dragmen are required, as the lecturer himself says, to do the work of horses; if we load down horses, they cannot do other work as well; so by loading the dragmen with rifles &c., &c., we absorb work and lose in efficiency where it is principally needed. As to the use of rifles on the field, if cover for the ammunition is sought at some distance, the dragmen will be needed to pass ammunition. Granting, however, which is doubtful, that there is in action *nothing* for these men to do, it would, no doubt, for that moment be satisfactory to have rifles in their hands; but the question still remains, whether as the rifles have to be carried to the field you have not sacrificed in drag power more than you have gained in the use of rifles, as, in any event you have other infantry on which to call. I confess to thinking that you have. Whatever the decision, the point must be kept clearly in mind in forming it, that you cannot both have your rifles, and not injure your drag power. You cannot both keep your cake and eat it. I think we all tend to fall into the error of loading men too much in our anxiety to leave nothing behind; and it should not be forgotten that our men always come to this kind of work without use or training to bear it, a fact which vastly affects the question of endurance. Such service ashore is but an incident in their life for which no adequate training can be given in the service. The lecturer affirms that the advocates of smooth bore field pieces for the Navy, give no clear reason for their preference. My own reason, be it good or bad, is this:—that our seamen are not expected to act against well equipped, highly trained troops, but rather against irregulars, generally in small bodies and at short ranges. For these purposes I believe our smooth bores to have the merits of greater simplicity and greater rapidity of fire.

Lieut. SOLEY. I am quite with the lecturer in what he says about drills. Unquestionably the most important drills are those which relate to the fighting efficiency of our men, and no drill should be omitted which can lead to such an effect. The practice, so much in vogue, of confining our infantry drills on board ship to the useless performance of ceremonies, instead of to the fighting instruction, cannot be too strongly deprecated. But particularly with the boat guns should the men be taught to shoot, and to hit a mark, whether it be from the deck of a ship, from a boat, or on shore. The men are called away to "arm and equip the boats" at least once a week in the majority of our ships, but how often are they sent away in the boats to fire at a target and to obtain the necessary familiarity with the service of the piece? The first thing to teach them is to use their own weapons, and when they are perfect at that, it will be time to talk about dress parades.

The necessity of having a perfect system of organization cannot be urged too strongly. It was this objection to thorough system and to hard and fast rules, which the gallant lecturer so strongly condemns, which led to the humiliating disasters at Formosa and at Fort Fisher, where the Navy had every opportunity to crown itself with laurels, but where it was ingloriously defeated, brave men's lives wasted, and treasure thrown away for the want of system in organization; and, at the risk of being thought French-ified, or of copying too closely the old world models, I would urge the adoption of a system which left very little to individual thought, and was rigidly enforced and scrupulously adhered to.

Next with regard to the number of pieces to be landed. It is quite true that in the Army, the proportion of two or at most four pieces to one thousand men is generally followed, but it must be considered how different are the circumstances under which they are called upon to operate. In the land forces the artillery moves with the army great distances and large

ammunition trains are required and used. In the Navy we land our guns for a service which on the average will not exceed two or three days, and we rarely attempt to operate far from our base. For a long march into the interior, or for any other special circumstances, we should have to modify our arrangements. As the lecturer says, one good repeater in the hands of an expert marksman would be very valuable, but we have not yet in the Navy either the repeater or the marksman, and if we had them they would be of very little use in searching a wood or in clearing a beach covered with underbrush. It is on the number of guns that we depend for cover in the first moments of landing, and the difficulty about the ammunition is readily met by carrying reserve ammunition in the boat which carries the gun, with special men detailed to bring it up. Under the ordinary circumstances of employing guns on shore, I do not think they are disproportionate to the infantry, and with regard to the landing of the Naval Brigade at Key West, not the least important feature was the ease and celerity with which the Artillery Battalion of eighteen pieces was handled by Comdr. Evans over a difficult and comparatively unknown country.

The question of the number of men needed for the service of the piece and their equipment is an important one, and here I differ entirely from the views advanced by the lecturer. Undoubtedly twenty men are required for each gun but they must all be for the service of the gun. The gun is the weapon for the whole gun detachment and they should have no other. Let them carry each man as much ammunition for the gun as possible; but beyond that they must be unhampered and free to devote all their strength to moving the piece. Eight cannoneers will not be sufficient, but the whole twenty will be needed to move the gun at a moment's warning. The safety of the cannoneers from infantry attack cannot be ensured by having a few riflemen in rear of the piece who are to be sent to one part of the field as infantry at one moment, and the next moment are required at their gun when it must be moved unexpectedly for any reason. The guns must always have an infantry support but let it be an infantry support and not the motive power of the gun. We never hear of the horses of a battery being taken very far away when the guns go into action; so we must be always ready to move our guns and as their usefulness depends in a measure on the celerity with which they are moved, let the men be kept at the guns. Again, if we encumber the men with a repeating rifle, which is heavy, with sixty rounds of small arm ammunition, and in addition an intrenching tool, haversack, blanket, and a passing box with one or two charges, they will rather need to be carried themselves, and will be of no use either as infantrymen or as dragmen. I confess I was once an advocate of the plan of arming a part of the howitzer crew with rifles, but I am satisfied that although it may work well on the drill ground, it would never do for actual warfare. With regard to the limber, I think we are better without it. It is cumbersome on board ship, and in the boats, and there are other ways of transporting ammunition.

The question of permanent supports is of more importance with the army than with us. In the Naval Brigade the guns cannot move any faster than the infantry, and are not likely to be separated from them: they always work with the infantry and should be kept on the fighting line in all deployed movements but their movements and all their arrangements are so intimately connected with the infantry that they are never likely to be without support. The lecturer has quoted from Major Hoffbauer very extensively. Let me read a few of Hoffbauer's maxims, which he has overlooked and which are applicable to the movements of our artillery equally with any other of his deductions.

"Reasons why the artillery should advance to short ranges. (1). The more open formation of the infantry attack. Moral effect. Advancing infantry derives new inspiration when the guns pass close by in eager advance, and their opening fire is heard.

(2) The advantage of being near at hand, to support the attack if checked, or to prepare the way for renewed efforts.

(3) The great advantage of close connexion with the infantry so that the artillery can coöperate at the right moment.

(4) The decreased liability of being masked by advancing infantry.

(5) The possibility of artillery accompanied by infantry advancing under a musketry fire at a range of a thousand paces and less."

I think the lecturer errs in attempting to make the artillery of the Naval Brigade too dependent on rules governing the use of horse artillery in an army. Our artillery is more nearly allied to the infantry and is infantry but with a different arm. Therefore I think the drill of our Naval Brigade artillery should be as simple as possible and conform as much as possible to that of the infantry. The piece should always be ready to move, and all changes from one order to another should be made as quickly as possible. Again he is disposed to consider the employment of very large bodies, whereas such occasions are very exceptional: generally the naval Brigade will consist of the men that can be spared from three or four ships at the most.

In comparing the smooth-bores with the breech loading rifles, I acknowledge that I am one of those who stick to the smooth-bores for our purposes for the present: in rapidity of fire, in charge of canister and shrapnel, they are superior; in range they are inferior; and circumstances must decide which will be the most useful: I myself lean to the idea that we must take the majority of smooth-bores with some rifles, but my experience with the three inch B. L. rifles thus far has not been such as to make me desirous of trusting to the breech loaders in a critical moment.

In considering the possibility of employing guns in case of landing to take possession of a town, I think it would be dangerous to land as the lecturer suggests. I should prefer to land in the open country near the town and make for the most commanding position from thence. He speaks of sending heavy guns on rafts &c. I believe there are no heavier boat guns in actual use now than the heavy 12 and even if there were they would be of very little assistance mounted on rafts as their means of propulsion would be so indifferent: but when he comes to landing the heavy guns of the broadside batteries of the ships we get almost beyond the scope of the lecture and might as well make requisition for a fortress and an army to garrison it.

For the other case of landing in the country, he supposes that we are to operate with an army which has no artillery. In this extraordinary case we are very properly to devote our energies to sending a thoroughly equipped body of artillerymen. There is only a certain number of guns supplied, and there are plenty of men to go along as infantry, and in this case I think he had better take along a few companies of blue jackets as infantry to act as permanent supports.

When the Naval Brigade pure and simple is landed I have already said that the number of guns furnished to the ships will not be too many for a simple descent on a coast. For operations to last several days and to take men away from their base the number must be decreased to suit circumstances: and in action I think the guns should be massed as much as possible and kept up with the fighting line.

With us simplicity of drill is the first necessity. In the army the artillery is an arm of the service, and the men attached to it spend their lives in perfecting themselves and those under them in the use of their weapons. In the Navy, it is an occasional exercise, a service still more occasional: but the fact that the service is occasional should be no argument justifying the neglect of the rules for handling the pieces or for manœuvering them in numbers. Therefore we require a system of instruction and drill which shall be so simple that its principles may be covered by a few broad rules, easily acquired and easily retained.

One word more. The lecturer wishes to turn us into soldiers because we

are going to operate on shore. I do not think we should ever forget that we are sailors. The name of sailor is almost our birth right and we should yield it on no occasion. Let us rather show that we are sailors ready and willing to perform any duty, particularly if that duty be to fight. Let us teach our men to handle properly every weapon which is given them, let us teach them to move together with order and celerity, and if after that we can combine some of the thorough instruction given to the soldier with the ready, alert quick minded and quick limbed activity of the sailor we shall have an ideal fighting man whether for sea or for shore. Let us have thorough organization, thorough equipment and thorough discipline but let our teaching and drill be that of sailors to sailors.

Lieut.-Comdr. Brown. I think that the lecturer is disposed to have too large views on the subject, as he considers the handling and disposition of much larger bodies of men than we are ever likely to use. On his own allowance of four guns to a thousand men. if we had the whole fleet from which to draw a landing party (allowing 25 per cent to remain on board) we should not have more than twenty-four guns: and as any expedition upon which we are likely to engage would not be apt to land more than one thousand, or at the most fifteen-hundred men, the number of guns would not exceed six: added to this is the fact that we do not expect to go far from our base under any circumstances, and therefore I think it is quite unnecessary to go into the domain of what I venture to call grand tactics.

With regard to the kind of gun that we want for this service, I am of the opinion that considering the great care with which the rifle must be handled lest its mechanism become disarranged, our old smooth bore, which can be hastily landed without any special care as to whether it gets into the water or not, has a decided advantage. Another important point to us is that it requires less training for the men, and with the numerous other drills to which it is necessary to attend, we are not likely to be able to make our men skilled field artillerists.

Lieut.-Comdr. Folger. While I otherwise concur in the remarks which the paper has drawn forth, I must make a plea for our steel rifled boat gun as compared with the smooth-bore. The former is capable of doing all the work of the latter and much more. It has greater range, greater accuracy, an immensely increased facility of manipulation in the bows of a boat, and its shell furnishes greater breaching powers with a larger number of pieces on explosion, and, weight for weight, its shrapnel a larger number of bullets.

It may be argued that the liability to injury through sand in the threads of the breech screw would militate against its use for naval purposes, but the parts are very accessible, and the most ordinary precaution will eliminate the difficulty. Its manipulation is certainly simple enough, rather more so, in fact, than with those in use in several foreign services, and our people are at least equally intelligent.

If it is desired to disembark in a hurry, the gun may be thrown over board with as little liability to damage as with the smooth-bore, if the breech-screw be first removed. With perhaps the solitary exception of its fitness for street fighting, for work against mobs and mob defenses, I think I should prefer the rifled gun.

Lieut. Kennedy. I do not think it fair to settle the question of rifled and smooth bore guns by reference only to the 3-in breech loader. It is true that the latter may be delicate and complicated but there is no reason why a muzzle loading rifle should not be used that would be as simple as a smooth bore, and which could be as roughly handled. With such a gun you could use any ammunition that you could with a smooth bore and it would be just as effective at close quarters, while at the same time you would have a gun that could be used for accurate firing at long ranges. I see no reason why the effectiveness of the smooth bore at close quarters and the accuracy of the rifle at long range should not be combined in the same weapon. Regarding the equipment of the dragmen, as the lecturer

says, we do not go ashore unless we are pretty certain of being successful and generally do not expect to move far from our base. In such cases we can afford to give the men some extra weight, if, by so doing, we add greatly to their efficiency and ability to protect the guns. When an expedition is sent out with the intention of moving long distances, we must omit something from the weight the men have to carry, and as the supply of ammunition for our gun is the first requisite of course the rifles must be left behind.

Comdr. MAHAN. With both muzzle and breech loading rifles, the system of giving rotation used by us, renders the time fuze very uncertain and I doubt a percussion fuze giving as good results with shrapnel, the principal kind of projectile, as a well timed time fuze. No one disputes the superior range and accuracy of the rifled piece. What is disputed is that our seamen, unless when attached to land troops, will be pitted against an army; will enter, so to say, on a regular campaign, or do more than go ashore for short periods, to meet forces not superior to themselves as soldiers, and inferior to them in morale and dash. In such cases the smooth bore is believed to have range and power sufficient, and to be at once simpler and more rapid in use.

Lieut.-Comdr. FOLGER. The Franco-German war illustrated very thoroughly the destructive effects of Shrapnel. It is true the Germans used the percussion shell a great deal at all ranges but they were also supplied with a time fuze. We ourselves are not unprovided. An elaborate series of experiments at the Washington Navy Yard in 1877-78 furnished very successful results from a device of Dr. Woodbridge.

Lieut.-Comdr. BROWN. I am perfectly willing to acknowledge the superior efficiency of rifled guns for use on board ship, but I do not think that we can afford to give up our smooth-bore boat guns. In speaking of the liability of the rifle to get out of order I referred not to some possible muzzle loader that we may have in the future, but to the breech loader which we now possess.

Lieut.-Comdr. FOLGER. I think I need merely mention the respective effective ranges of eighteen hundred yards and forty-five hundred yards and ask the gentleman to compare the relative amount of harm which could be inflicted upon an enemy, in an expedition, let us say, up one of those rivers in China which flow through miles of flat, low land with an accessible village at every bend of the stream.

Lieut.-Comdr. BROWN. This would be an exceptional case and hardly in the line of field artillery; under ordinary circumstances we do not need to use boat guns at a range of four thousand yards.

Lieut. MASON. It is not always possible to gather the full meaning of arguments from merely hearing them read. Most of the questions that have been raised this evening were foreseen by me and I attempted to answer them. I have been much pleased to find that so few flaws have been detected, especially by so intelligent a body of my brother officers. The two principal points of difference are, as they naturally would be, the armament of the individual and the battery. Even the opponents of the system of arming a part of the crew with rifles, grant the advantage that would be derived from them in the decisive moments of a battle. The battle is what we most desire to be prepared for. On the march we may use as many of our infantry as we desire to lend a hand on our drags, but in action with the limited number of men we would have, we will need every infantry man for his legitimate duty and not to entrench and protect our guns. Two of the gallant officers have so well sustained the merits of the breech loader that I can only say in addition in regard to the fuzes, it is my experience that the Borman fuze used with our smooth-bores is quite as unreliable as those used with our rifles. The Chief of Ordnance some little time since endorsed on a report of a fuze for the base of a shell the following: "The Chief of Bureau is of the opinion that there is no necessity for a fuze in the base of the shell. So long as we use the expanding system, *the pro-*

*portion of failures to ignite the fuze is not greater in the rifle than in the smooth-bore shell;* nor as far as a limited series of fires by the army would show, than with a rear fuze."

In regard to seamen not being able to endure the fatigues of soldiers, I would say that wherever in our own service, or in that of other countries, they have been pitted against each other the sailors, from their general active outdoor life, have been found fully equal to the soldiers. This was notably the case in the late Ashantee expedition. I have it on the best authority that repeaters are to be furnished immediately to at least one of our ships.

It is not proposed to limit the number of *boat-guns,* which would cover the landing but only those to be used as *light-artillery.* On the contrary as large a number as possible is advocated.

Circumstances, which must always alter cases, might require us to land outside of the town, in which case it would be treated as such a case. The weakest point in or out of the town would of course be the one selected.

When I spoke of using the guns on rafts in preference, on some occasions, to boats, I had in view the new Gondola raft which has just been introduced as part of the equipment of every vessel and which is I think unknown to my gallant friend or he would perceive the advantages under certain circumstances, to be derived from being able to mount the gun on a platform sixteen by ten which could be surrounded with a hammock breastwork and towed, pushed or rowed into very shallow water. In the "Manuel du Cannonier" a contrivance, for a similar purpose, made of casks is advocated. The landing of the ship's great-guns would only take place under special circumstances and does not, properly, come under the head of my subject but if not taken into it, it would hardly find a place in any other. That our great guns have been landed, and with effect too, officers who served at Vera Cruz, Mobile or Morris' Island can fully prove.

In regard to the position of artillery in the field I know that practically the officer who argued that point agrees with me. He looked at it, however, through the eyes of one who wishes to subordinate artillery to his own adopted branch. Short range for artillery is not short range for infantry. In speaking of pushing up the artillery into the fighting line, he cannot mean to put it in the advanced line of skirmishers, especially masked. In such a position he would certainly need all his crew at hand as cannoneers and probably before long would have used up all his infantry for the same purpose.

I do not desire to make a soldier out of a sailor, although literally we are all soldiers. Soldier being derived from *solde, pay,* soldier, one who receives pay. I want the sailor to *act* as a soldier, never forgetting that he *is* a sailor and applying at all times that feeling of personal responsibility and that individual intelligence which his daily life fosters.

No extra limber is advocated. It is proposed to use the carriages of the guns left in the boats or aboard ship for that purpose. It might be dangerous and inconvenient in regard to the supply of ammunition to have a mixed battery of guns. *Uniform* system and caliber are to be advocated, whichever is chosen. If they are to be breech loading rifles let all be such. If they are to be smooth bore 12 pounders let all be the same.

It was not my intention to have nor do I think that I have, touched upon the subject of "*Grand Tactics.*" I have tried to be guided in my conception of what might happen by what has already happened. I have not cited a single case where a parallel cannot be found in naval history. In conclusion I would thank you for the interest which you have taken in the subject of the lecture, and I hope, for one, that one of our gallant members may be induced to give us his ideas in regard to the employment of the Naval Brigade.

The Chairman.—I agree with what has been already said about the equipment of howitzer-crews. In actual service in the field, I found that men could only carry a blanket and one round for the piece; I therefore

took away from them all arms, as I considered one round for the howitzer more valuable than the rifle a man can carry without it. Besides, artillery-men should be taught to rely solely upon their pieces for defence, and I should fear their leaving them and taking to their rfles, when hard pressed, if supplied with them.

The crew, as it is, is not too large for the service of the piece in action and to move it to the front and rear "by hand" on smooth ground. In sandy, or muddy soil, it will be found necessary to move it by the "drag" even over very short distances.

Many of the arguments brought forward by the lecturer are familiar to me, but they were intended to apply to horse-artillery, not to the light howitzer of the Naval Brigade, which can easily maintain, or retreat from its place with the infantry on the fighting line. At the battle of Bull Run, the 71st New York Regiment carried two of our Dahlgren heavy smooth-bores into action, and they were the only guns brought off the field. All the horse-artillery fell into the enemy's hands.

The vexed question of rifles versus smooth-bores for the field admits of much argument. It seems to me that a battery should be composed of one-third rifles to two-thirds smooth-bores, as the latter, in my judgment, will do most execution at short range, and in a decisive battle, men get pretty near each other by the time victory or defeat hangs in the balance.

One thing is clear to me, that no arm which will not stand rough handling by rough men is good for anything in time of war. I scout the idea that sailors become soldiers in battles on shore. I say it is the province of the *sailor* to learn to handle small arms intelligently and that he has no superior as an *artillerist*, afloat or ashore. The marines who assist Jack in swinging the main-yard do not become sailors thereby.

I will not say more now as the discussion has been quite full, but I am sure that all will concur with me in tendering thanks to the lecturer for the interesting paper which we have heard.

# THE RECORD

OF THE

# UNITED STATES NAVAL INSTITUTE.

NAVY DEPARTMENT, WASHINGTON,

MARCH 27, 1879.

The President, Rear-Admiral JOHN RODGERS, in the Chair.

## REVOLVING STORMS, OR HOW THE WINDS BLOW WITHIN THE STORM DISK.

By LIEUTENANT COMMANDER THOMAS NELSON, U. S. N.

MR. PRESIDENT AND GENTLEMEN :—

Not very many years ago, probably quite within the recollection of

## ERRATA.

| | | | | | |
|---|---|---|---|---|---|
| Page | 234, | line 1 | from top, | for | hav- read having. |
| " | 236, | " 19 | " | " | " Thorn read Thom. |
| " | 247, | " 16 | " | " | " outside read outward. |
| " | 247, | " 24 | " | " | " port-side read port side. |
| " | 253, | " 3 | " | bottom, | for 29.19 read 27.19. |
| " | 258, | " 8 | " | " | " Lew read Leu. |

Later, however, several other scientists have taken up the subject of storms and by various methods of investigation have arrived at different conclusions. Some of them have gone so far as to say that the circular theory is all wrong, and the rules for navigation based upon it are worse than useless, and the question to-day is: How the winds blow within the stormdisk?

It is with this question that I propose to deal this evening, and in doing so will endeavor to confine myself to facts from which every one may draw his own conclusions and judge of the correctness of mine.

took away from them all arms, as I considered one round for the howitzer more valuable than the rifle a man can carry without it. Besides, artillery-men should be taught to rely solely upon their pieces for defence, and I should fear their leaving them and taking to their rfles, when hard pressed, if supplied with them.

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MARCH 27, 1879.

The President, Rear-Admiral JOHN RODGERS, in the Chair.

## REVOLVING STORMS, OR HOW THE WINDS BLOW WITHIN THE STORM DISK.

By LIEUTENANT COMMANDER THOMAS NELSON, U. S. N.

MR. PRESIDENT AND GENTLEMEN :—

Not very many years ago, probably quite within the recollection of some of the old officers of the navy, the great ocean storms were very imperfectly understood and marine disasters were frequent and terrible. The attention of several scientific men was attracted to the subject and eventually Mr. William Redfield of New York discovered after long and careful investigation into the matter, that the winds in these storms blew in circles round a center of low pressure, and that the great number of marine disasters were mainly due to ignorance of this fact.

Certain rules for the management of ships in a storm were published and proved a great blessing to seamen, who, by observing these, were enabled to escape the dangerous part of it, either by running away from the center, or by heaving to in time on the proper tack and letting it pass.

Later, however, several other scientists have taken up the subject of storms and by various methods of investigation have arrived at different conclusions. Some of them have gone so far as to say that the circular theory is all wrong, and the rules for navigation based upon it are worse than useless, and the question to-day is : How the winds blow within the stormdisk?

It is with this question that I propose to deal this evening, and in doing so will endeavor to confine myself to facts from which every one may draw his own conclusions and judge of the correctness of mine·

By way of introduction I will touch briefly upon the history and progress of this, to seamen, all-important subject, and mention only a few of the principal cases that were published in the newspapers and scientific journals of the time, and which doubtless served to call the attention of scientific men to the matter, as also to arouse the spirit of investigation and a desire to clear up the mystery which enveloped the entire subject at that time, by comparing and generalizing observed facts, as reported from time to time by men who had the good fortune to escape with their lives from the terrible storm center, and to come back and tell the tale of the fearful things they had seen.

The first authentic information relating to circular storms (which, for the sake of brevity I will call cyclones) was published in England (Philosphical Transactions, October, 1698) in a paper on the West India hurricanes by Captain Langford, who speaks of the storms as whirl-winds, describes the veering of the wind, and the progressive movement of the whole storm.

The Spanish navigator, Don Juan d'Ulloa, during a cruise on the Pacific coast of South America in the year 1743 experienced several storms in which the wind changed from north to west,* (which would occur in the northeast quadrant of a cyclone in the southern hemisphere traveling southward and eastward).

A French writer named Romme, in a work entitled "Tableaux des vents, des marées et des courans" published in 1806, describes storms in the China Sea near the gulf of Tonkin, which he distinctly calls whirlwinds, and applies the same name to other storms experienced in the Mozambique channel, and again others in the gulf of Mexico.

Professor Farrar, of the Cambridge University, Mass., in describing a storm that passed over Boston on 23d September, 1815, (the account of which was published in the American Philosophical Transactions 1819) says, that he could not determine the place of the center or the limits of this storm, but noticed the veering of the wind, and the fact, that it veered in opposite directions at Boston and New York at the same time.

Before this, in 1801, Colonel James Capper published a work entitled "Observations on the winds and monsoons," in which he speaks of great whirlwinds on the Coromandel coast, the centers of which pass generally, near Madras or Pulicat, and whose diameter, he says, cannot exceed one hundred and twenty miles.

* Piddington page 82 and Dove's Law of Storms, page 108.

The above would seem to indicate that both Romme and Capper had noticed the rotary motion of the wind in storms; but it also appears that they considered these storms merely local, and they had evidently not conceived the idea that the great ocean storms might be governed by the same laws.

In the year 1831, Mr. Wm. Redfield, an American philosopher, published in the American Journal of Science, a paper, in which he demonstrated not only that the storms on the American coast were whirlwinds, but also that they had a progressive or forward movement, travelling on curved tracks at a considerable rate, and were traceable from the West Indies, along the coast of the United States, curving off to the eastward at some point between the Bermudas and the banks of Newfoundland.

While Mr. Redfield was employed collecting the data from which he eventually deduced his law of storms, a similar investigation was going on in Germany. A number of gales had attracted the attention of German meteorologists, chiefly on account of the oscillations and great fall of the barometer, before and during these gales. On Christmas eve, 1821, the barometer sank so low that many people believed their barometers were out of order, and others, who were not mistaken as to the cause, expected a great catastrophe.

Professor Brandes, a German meteorologist, who had kept a record of observations for a length of time, obtained the registers kept at various places during the same time, and eventually advanced a theory, that the winds, during these great storms, blew from all points of the compass in straight lines toward a central space where the barometer was for the time at its lowest stand.

The theory of Mr. Brandes was disputed by professor Dove of Berlin, who subjected the observations to a new examination, and made it appear that an explanation of all the phenomena was afforded by the assumption of one or more circular currents or whirlwinds of great diameters, advancing from S.W. to N.E. A full account of this is found on page 162, Dove's Law of Storms, 2nd. Edition 1862.

Professor Dove's theory, although under discussion about the same time that Mr. Redfield by an independent course of investigation arrived at the results above mentioned, was not known in the United States when the latter gentleman published his paper in the American Journal of Science, and an eminent English philosopher, named Sir David Brewster, is accredited with saying in connection with Redfield's discovery : " The theory of rotary storms was first suggested by Colonel

Capper, but we must claim for Mr. Redfield the greater honor of having fully investigated the subject, and apparently established the theory upon an impregnable basis. Mr. Redfield had no knowledge of Col. Capper's discovery, when he published his own in 1831." *

In the year 1838, Lieutenant Colonel Reid, of the royal engineers, published a valuable work entitled "Reid on the law of Storms," in which he agreed in all particulars with the views of Redfield, and verified by personal observation all his theory; adding many substantial proofs to the same by investigations of some of the West India hurricanes, and of some in the southern Indian Ocean.

Colonel Reid by his observations of storms in this latter sea further proves Mr. Redfield's theory, that, the storms in the southern hemisphere revolve in a contrary direction, to those in the northern hemisphere. Colonel Reid embodied in his work many useful rules for manœuvring in a revolving storm, and thus may be said to have reduced the science from a mere speculative theory to a practical law; and the recorded experience of hundreds of able and observing men who have carefully and intelligently noted and studied the course and gradual veering of the wind within the limits of the storm disk goes to prove, that correct conclusions have been arrived at in this respect, and that in every part of the world where these storms have been met with, the winds rotate in concentric circles, with greater or less velocity according to the distance from the center; from right to left in the northern hemisphere, and from left to right in the southern hemisphere; but these principles are so well known that it is unnecessary here to dwell upon them.

With respect, however, to the cause or origin of cyclones we are still comparatively in the dark, and as it is not my purpose to introduce any new theory, nor even to criticize existing ones, except so far as they may conflict with my own views, I shall confine myself to a brief recital of the opinions of a few gentlemen who appear to have given the subject careful consideration, and spent much time and labor in the prosecution of their investigations; and whom, I would add, though time shall prove all their theories wrong, are nevertheless entitled to the gratitude of all the world, and particularly to the love and reverence of "those who go down to the sea in ships."

Mr. Redfield appears to have had no particular theory as to the causes of cyclones; he thought it would be unscientific to attempt to account for them, until better informed, by the exclusive action of any

* Reid on the Law of Storms, page 2. Third edition. 1850.

one or more causes. Later, however, he inclines to think them produced by the conflicts of prevailing currents in the different strata of the atmosphere giving rise to circular movements, which increase and dilate to storms.

Colonel Reid avoids any general speculation as to the causes of cyclones. He adverts to the possibility of there being some connection between storms and electricity and magnetism, and concludes with an account of an experiment with a ten inch hollow shot, which he thinks, partly confirms his views.*

Professor Dove accounts for cyclones, by currents of air near the equator being from any cause set in motion toward the poles and coming in contact with other currents moving in a different direction.†

Mr. Piddington, the author of the Sailor's Horn-book, in the 3d edition of that work, (1860) pp. 324, 325 and following pages, gives it as his opinion that cyclones are purely electrical phenomena formed in the higher regions of the atmosphere, and descending in a flattened disk-like shape to the surface of the ocean, where they progress more or less rapidly, according to circumstances. He thinks that whirlwinds, dust-storms and water spouts are the same meteor in a concentrated form, but cannot say where the law which regulates the motions of the larger kinds ceases to be an invariable one.

The views of Sir John Herschel on the causes of cyclones, says Mr. Piddington, (Sailor's Hornbook, page 21) may be briefly stated as follows:

"It seems worth inquiry whether hurricanes in tropical climates may not arise from portions of the upper currents prematurely diverted downwards before their relative velocity has been sufficiently reduced by friction on, and gradually mixing with, the lower strata; and so dashing upon the earth with that tremendous velocity, which gives them their destructive character, and of which hardly any rational account has yet been given. Their course, generally speaking, is in opposition to the regular trade winds, as it ought to be in conformity with this idea." He then goes on to say that it does not follow that this must always be the case, for, "in general, a rapid transfer, either way in latitude, of any mass of air which local or temporary causes might carry above the immediate reach of the friction of the earth's surface, would give a fearful exaggeration to its velocity. Wherever such a mass should strike the earth a hurricane might arise, and should two

* Reid on the Law of Storms. 3d. edition, 1850—page 490.

† "Dove's Law of Storms." 2nd edition, 1862—page 182.

such masses encounter in mid-air, a tornado of any degree of intensity on record might easily result from their combination."

Sir John Herschel also alludes to the possibility of the meeting of two atmospheric undulations or barometric waves travelling in different directions, producing a storm and giving a rotary motion to the wind.

Professor Espy, an American philosopher, in his fourth meteorolgoical report, 1857, page 11, gives as one of the causes of storms the following: upon any partial heating of the air at the surface of the earth it rises in columns more or less charged with vapor, which as they rise have their vapor condensed into clouds or rain. Next in this changing of state the vapor communicates its latent caloric to the surrounding air, which also expands, is cooled itself by that expansion, but also gives heat to that part of the air in which it is then, and becoming lighter is carried farther up. In short Mr. Espy considers the center of a storm the base of a huge moving chimney circular or of any longitudinal shape, the draught of which is occasioned by an extensive condensation of vapor above.

Dr. Alexander Thorn, in a work on storms in the Indian ocean, south of the equator, gives it as his opinion that circular motion is given to the winds in a storm area by the contact in meeting on the borders of the monsoons and trade winds of opposing currents of air, differing in temperature, humidity, specific gravity and electricity. These he thinks give rise to a revolving action which originates the storm.

It is believed by some that cyclones originate at great volcanic centers, and Mr. Henry Piddington is among that number. On page twenty-three, sailor's Hornbook, I find the following: "If we produce at both ends the line of the track of the Cuba cyclone of 1844, we shall find that it extends from the great and highly active volcano of Cosseguina on the Pacific shore of Central America, to Hecla in Iceland. And in 1821, the breaking out of the great volcano of Eyafjeld Yokul in Iceland which had been quiet since 1612, was followed all over Europe by dreadful storms of wind, hail and rain."

A late writer, (Professor Silas Bent) in an article published in the St. Louis Republican, Nov. 3d 1878, gives the following interesting solution of the cyclone problem, viz: "By the earth's rotation on its axis, objects on its surface between the tropics are carried from west to east at the rate of a thousand miles per hour, whilst, as we advance towards the poles, this rate decreases with the decrease in the circum-

ference of the parallels of latitude, so that when we arrive at points where the circumference is only twelve thousand miles instead of twenty-four thousand as it is at the equator, this velocity of rotation is but five hundred miles an hour, and so on, decreasing until reaching the pole."

"Now an object set in motion towards the equator, from the polar regions, where the velocity of the rotation is small, will constantly be arriving at points on the earth's surface where the velocity is greater, and, not at once acquiring this greater velocity, its direction will tend obliquely to the westward. Hence we find those streams or currents which flow from the pole towards the equator, always taking a south-westwardly direction, whenever the continents and islands will permit. As another and perhaps more forcible illustration let us suppose that a cannon at the pole be fired in the direction of Mount Chimborazo, on the equator, and that the ball travels at the rate of one thousand miles per hour. The distance from the pole to the equator being in round numbers six thousand miles, it would take the ball six hours to reach the equator; but, during that interval, Chimborazo has been whirled six thousand miles to the eastward and the ball would strike the equator six thousand miles to the westward of the mountain, and in its flight would have made a due southwest course from its point of starting. The result would be the same, of course, whether the ball be fired from the south or the north pole, and this shows why the trade winds, which strive to take the shortest flight towards the equator, are swept to the westward and are given their oblique direction."

"For similar reasons all ocean and atmospheric currents, flowing from the equator towards the poles, being subject to the same physical laws, are thrown to the eastward in both hemispheres."

"Fluids flowing freely towards a center always assume a rotary movement, as is seen in wash basins when the plug is removed from the waste hole."

"Now let us suppose that a disturbance in the equilibrium of the atmosphere has taken place by which a lessened atmospheric pressure or partial vacuum occurs a number of degrees north of the equator, and to restore which the surrounding air is set in motion towards this common center."

"The air nearest the equator, in moving north, will be thrown to the eastward; whilst that to the north of the vacuum, in flowing south, will be thrown to the westward; but both will at the same time be pressed inwardly towards the vortex by the heavy mass of the atmos-

phere without, and these two movements in opposite directions and on opposite sides of the incipient storm will give a revolving direction from left to right (right to left?) to all intervening portions of the atmosphere to complete the gigantic whirlwind which is thus generated."

"Shift the phenomenon to the southern hemisphere, and all the characteristics remain the same, but the rotation of the storm will, under the operation of precisely the same physical causes, be in the reverse direction; that is, it will be from right to left (left to right?) or with the hand of a watch, instead of from left to right (right to left?) as described in the northern hemisphere."

Before closing this part of the subject I must refer to another writer of some prominence in meteorology, Professor Wm. Blasius, whose book entitled "Storms, their nature, classification and Laws" was published in 1875 and shows its author to be a profound thinker and indefatigable investigator in search of truth. The space in this paper does not admit of a rehearsal of his theory, but a full and exhaustive account of it will be found in his book on storms above mentioned, page 44 and following pages, and also Appendix A of the same book, page 256 and following pages.

His laws governing the motion of the wind in a storm are most singular and entirely at variance with anything heretofore heard of or experienced by seamen; and his rules for avoiding the dangerous portion of a storm are very extraordinary. Thus on page two hundred forty-three he says: "In the temperate zone, if the cumulo-stratus, in dicating a southeast storm is seen above the southern horizon, there is no danger, because the storm will go south. If it appears in the north, it will approach with the dangerous region in advance, and it is wisest to sail by the shortest course to the outside of the track, guided by the position of the cloud and its progressive direction. If the storm is yet distant this may be easy. If however a vessel should find herself immediately in front of the middle of a southeast storm, not yet fully developed, the wisest course is probably to sail straight through the region of calm into the polar current."

I presume the professor in his last remark has reference to a steamer.

With respect to the centripetal or inblowing theory, advocated and developed by Professor Espy of Philadelphia, Mr. Blasius says (page 39) that it contains more of the germs of truth than the cyclone theory, and he admits that it is true as far as it goes, but that it is in the position of a part of the truth seeking to take the place of the whole truth. Now if the centripetal theory is true as far as it goes, then every

ship scudding in a storm must run into the center, and that we know is not true; for there is no case on record nor is it known in the experience of any seaman that a vessel has ever got into the center of a cyclone by scudding, except, when she has attempted to cross the storm track when the distance of the center and the velocity of the storm on its track rendered such a thing impossible. I ought to say that there is no well authenticated case on record, for there is indeed a case recorded in the book on Storms by Professor Blasius above referred to, which may be found on page 241 of that work, as follows: "Mr. Meldrum has published a treatise to prove that cyclones are not circular but elliptical in shape, formed between two opposing currents of air, and states that the rules based on its being circular frequently carry vessels into the dangerous section instead of around it. He cites the startling fact that on February 25, 1860, forty-one vessels left the roadstead of Réunion island with a south-easterly wind, which, according to the old law of storms, placed the vortex to the northeast, and these vessels sailed to the northwest to avoid it. The result demonstrated that the central vortex was really to the N.N.W., so that they ran directly into it, and only four of them, one a steamer, succeeded in crossing the storm path. As for the remaining thirty-seven, only seven escaped total loss or very great injury.

In the proper place in this paper I will again refer to this case; and it is perhaps proper to state here also, that in a foot-note on page 241, Professor Blasius says that he was obliged to rely for the above quotation on a newspaper paragraph, having been unable to obtain Mr. Meldrum's treatise.

Other opinions on the origin of cyclones are not wanting; but the object of this paper being not to deal so much with the theoretical cause of cyclones as with the effect and the practical application of the theory, I will close this part of the subject here, and pass to the narration of a few facts gathered by myself from original sources.

Professor Blasius in his book on storms page 240 says: "In the first place it is deduced from our principles that the rotary or cyclone theory is radically wrong, and the rules for navigators which are based on it worse than useless." Let us examine and see how far this statement is borne out by facts.

On the twenty-fifth of August, 1872, while attached to the U.S.S. *Idaho* at anchor in the harbor of Yokohama, Japan, a cyclone passed over that place; and I was enabled, from my fixed and secure position onboard the ship, to observe accurately all the phenomena of the storm, which I did and of which I here give an abstract.

At four P. M. the storm commenced, wind at E.S.E. force 6 to 9, barometer 29. 28 in. thermometer 80° and the weather overcast and squally with rain.

At five P. M. wind still E.S.E., force from 9 to 10, barometer 29.14 in. having fallen 0.14, during the hour, heavy clouds resting on the water, and the squalls coming with redoubled force at shorter intervals than during the preceding hour.

At six P. M. wind E.S.E. ¼ E., force from 9 to 11, barometer 28.94 in., having fallen 0.20, during the hour; clouds darker and if possible thicker, and the rain pouring down in torrents.

At seven P. M. wind E.S.E. ½ E., force 11 to 12, barometer 28.50 in., having fallen 0.44 during the hour. Up to this time the wind had blown in squalls, lasting from three to five minutes, which are represented by the highest figures here given to denote force of the wind while the lower figures indicate the force of the steady gale; but during the five minutes succeeding seven P. M. the wind blew with a steady force which I cannot describe by any language at my command except, perhaps, by comparison. In which case I would say, that this terrific blast bore the same relation to the highest steady force of the storm previously experienced that an ordinary fresh gale bears to a light breeze; and the rain, which continued to fall in torrents, was blown by the force of the wind into such fine particles that it assumed the appearance of a moist vapor driven furiously before the storm, but notwithstanding it fell so fast on the *Idaho's* deck that the scuppers were insufficient to carry it off. During this blast, an English bark at anchor in the harbor near the *Idaho*, which had not at all moved during the rest of the storm, picked up her moorings and dragged past the *Idaho* at the rate of, I judged, about six knots, and had the blast lasted ten minutes longer she must have brought up on the Kanagawa shore, but at 7.05, P. M. the blast was over, and the wind gradually subsided, veering as it did so to the southward, and shortly after an entire calm followed.

The barometer still kept falling, and at 7.15 P. M. it stood at 28.35 in., having fallen 0.15 in. in fifteen minutes. During the calm the weather was fine, the rain had entirely ceased, and the sky overhead was partially clear. At 7.30 P. M., the barometer reached its lowest stand, 28.27 in., having fallen 0.08 in. in fifteen minutes. The calm lasted about half an hour. At 7.45 light airs were felt from N.W. and at 8.00 the shift came in force from W.N.W. ½ W. with a re-appearance of rain and violent squalls. The barometer, in the mean time, had commenced to rise, standing at 8.00 P. M. at 28.32 in. At 9.00 the wind

## EXPLANATION PLATE I.

Fig. 1. *Scale approximate: 1 inch = 40 miles.*

LONG ARROW represents axis of Storm track. *Figures*: 1, 2, 3, etc, encircled by small arrows, mark positions of storm center corresponding to reference points on the track similarly marked.

BROKEN LINE, represents ship's track.

*Small circles* numbered 1, 2, 3, etc. mark ship's position for each point of reference and referred to the corresponding numbers on the storm track show approximately bearing and distance of center, measured on the double dotted lines.

LONG ARROWS pointing to ship's positions on the track, indicate, the true or actual, and the *short arrows* the corresponding cyclone winds.

DOTTED PERPENDICULARS raised on the storm-track from centers 6 and 7 mark the points between which the ship passed over the apex of the elliptical figure of the storm-disk.

*Dotted perpendicular* at center, 9, marks the point at which the influence of the land upon the wind, commenced to decrease.

Fig. 2. *Scale approximate: 1 inch = 120 miles.*

Represents right semi-circle of storm-disk.

HULKS, numbered 1, 2, 3, etc. show positions of ship in the storm-disk, corresponding to reference points on ship's track and storm track (Fig 1) similarly numbered and are plotted by bearing and distance from center.

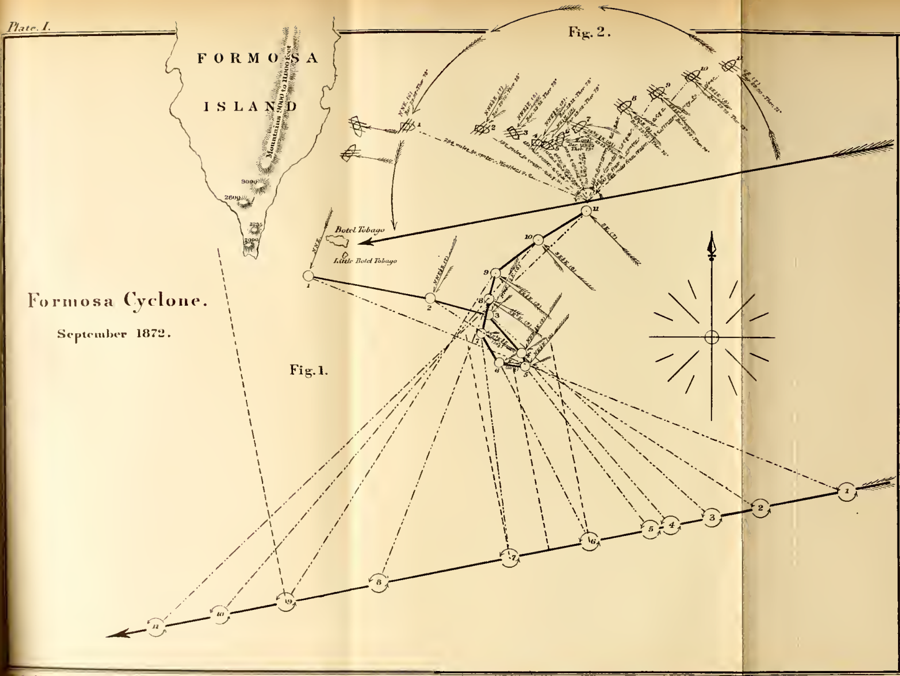
STRAIGHT ARROWS pointing to hulks indicate true or actual direction of winds.

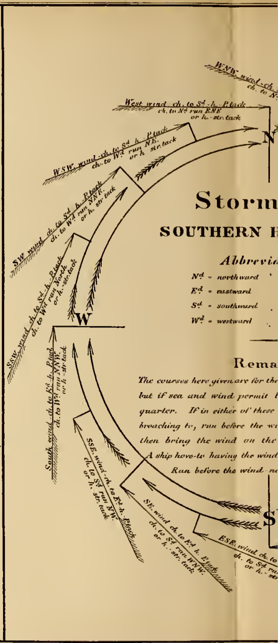
*Short curved* arrows show the corresponding cyclone winds.

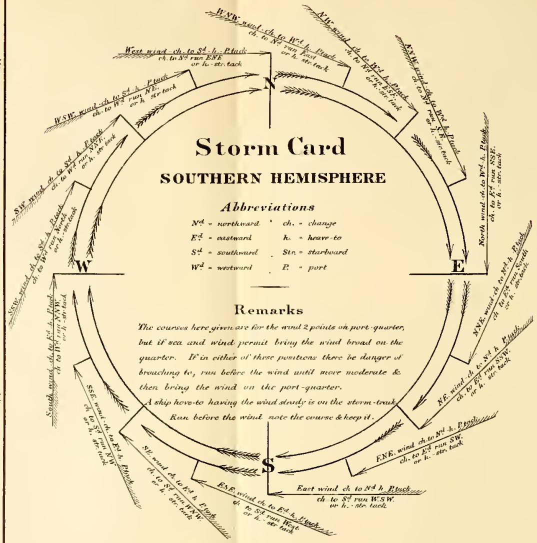
LETTERS above arrows show the direction, and *figures* in brackets near them, the force (Beaufort's scale) of the winds.

*Letters and figures* below arrows, show state of barometer and thermometer as observed on board ship.

HULKS (2) near the east coast of Formosa represent a ship on either tack in a dangerous position after center passes westward of island.


FORMOSA
ISLAND
Mountains 9000 to 11000 feet
9000
2600
Botel Tobago
Little Botel Tobago
Formosa Cyclone.
September 1872.
Fig. 1.
Fig. 2.


Storm
SOUTHERN H
Abbrevia
N$^d$ = northward
E$^d$ = eastward
S$^d$ = southward
W$^d$ = westward
Rema
The courses here given are for the
but if sea and wind permit
quarter. If in either of these
broaching to, run before the wi
then bring the wind on the
A ship hove-to having the wind
Run before the wind
W
N
S


Storm Card
SOUTHERN HEMISPHERE
Abbreviations
N^d = northward
E^d = eastward
S^d = southward
W^d = westward
ch. = change
h. = heave-to
Str. = starboard
P. = port
Remarks
The courses here given are for the wind 2 points on port-quarter, but if sea and wind permit bring the wind broad on the quarter. If in either of these positions there be danger of broaching to, run before the wind until more moderate & then bring the wind on the port-quarter.
A ship hove-to having the wind steady is on the storm-track.
Run before the wind note the course & keep it.
N
E
S
W
West wind - ch. to S^d. - h. - P. tack
ch. to N^d run ENE
or h.-str. tack
East wind ch. to N^d h. P. tack
ch. to S^d run W.S.W.
or h. - str. tack


Storm Card
NORTHERN HEMISPHERE
Abbreviations
N^d = northward
E^d = eastward
S^d = southward
W^d = westward
ch. = change
h. = heave-to
Str. = starboard
P. = port
Remarks
The courses here given are for the wind 2 points on the starboard quarter, but if sea & wind permit bring the wind broad on the quarter. If in either of these positions there be danger of broaching-to run before the wind until more moderate & then bring wind on starboard quarter.
A ship hove-to having the wind steady is on the storm-track.
Run before the wind note the course & keep it.
N
E
S
W
East wind ch. to S^d. - h. - Str. tack
ch. to N^d run WNW.
or h.-P. tack
West wind - ch. to N^d - h. - Str. tack
ch. to S^d run ESE.
or h. - P. tack

was W. by N. and barometer 28.70 in., showing a rise of 0.38 in. during the hour; the wind at this time blew with a force of from 8 to 10. At 10.00 P. M. the wind had veered to west and moderated to a strong breeze; barometer stood at 28.93, showing a rise of 0.23 in. during the hour. The rain at this time ceased. At 11 P. M. wind had moderated to a light breeze, and soon after died away altogether, blue sky appeared and barometer rose to 28.99 in.

The storm had passed, travelling in a direction about N.N.E. at the rate of fifteen miles an hour, and its diameter was about one hundred and five miles. I had excellent opportunity for obtaining data relating to this storm and the above figures are very close approximations to the truth. A remarkable feature of this storm was the almost total absence of lightning, for, with the exception of a few very vivid flashes on either side of the center, there was no appearance of any electrical phenomena during the entire passage of the storm over the ship. I observed also during the passage of this storm over the *Idaho*, at irregular intervals, sometimes during, and at other times between the squalls, a violent vibration of the magnetic needle, which was not caused by the movement of the ship nor by any vibration communicated to the compass by the force of the wind causing the ship to tremble as she did during the heavy squalls and the final blast; and I can only account for this by the assumption of a strong magnetic force being distributed in veins or bands through portions of the atmosphere in the stormdisk.

The above facts speak for themselves, and, having observed them myself, I am certain of their correctness. The one thing I cannot do is to reconcile them with the centripetal or any other than the cyclonic or circular theory.

## FORMOSA CYCLONE.

The British ship *Argyleshire*, on a passage from Hong Kong to Yokohama, encountered, on the 11th September 1872, at midnight, a cyclone near the south end of Formosa; Botel Tobago island bearing N.E. twenty-three miles, when the wind commenced to blow fresh from N.N.E., accompanied by all the usual signs of bad weather, and the captain rightly concluded that he was on the border of a cyclone; but somewhat hastily, and, as I will show, wrongly, decided that he was in left semicircle.

On the diagram marked Formosa, Plate I. Fig. I, I have plotted the track of the ship from the time of her entrance into, to the time of her

departure from the stormdisk, the courses and distances, being the true courses and distances, resulting from a careful computation of the data found in her log. Points of reference on the track are marked 1, 2, 3, &c.

Fig. 2. shows the actual position of the ship in the stormdisk, plotted by bearing and distance from the center, and the points of reference 1, 2, 3 &c correspond to the same numbers on the track.

I have also drawn roughly the coast line of Formosa, in order to show the relative positions of ship and land, and also to illustrate the effect of high land upon the wind in a cyclone.

By an examination of the log book of the British bark *Malvera,* I found that she had passed through a portion of the same storm, and, by the data contained in her log, I was enabled to locate the center fifty-five hours after it had passed the *Argyleshire,* during which time it had travelled W. by S. four hundred and sixty-one miles. This of course is only approximate, but it is probably not far from the truth, and I have therefore constructed this diagram on the assumption of a uniform rate of speed of 8.4 miles per hour W. by S. With this, and the data found in the *Argyleshire's* log, I have also computed its diameter to be about five hundred eighty eight miles.

But to return to the ship we find her on the border of the cyclone (Pt. I) having the wind from N.N.E. and the center bearing according to the accepted theory of the law of storms: E.S.E., barometer 29.95 in., weather overcast and cloudy. The captain, believing that the storm was moving northward, decided that he was in the left semicircle, and accordingly continued on his way making good a course E. by S. (on the port tack) for a distance of sixty-three and a half miles, during an interval of five hours and eighteen minutes. At this point (Pt. 2), the wind had increased so as to oblige him to shorten sail, and the barometer had fallen to 29.70 in., the squalls become stronger, more frequent and of longer duration. He still continued on his course believing that the center would pass northward far enough ere he could reach the line of its axis to enable him to take advantage of the westerly and south westerly winds, which he expected to meet with in the south and south-eastern parts of the storm circle; but at the expiration of three hours the wind had increased to a moderate gale, blowing from N.N.E. ¼ E., barometer had fallen to 29.32 in. and the condition of the weather grown very much worse. During the last three hours he had made good a course E.S.E. ¾ E. thirty miles (Pt. 3). Sail was again reduced and during two and a half

## EXPLANATION PLATE II.

Fig. 1. *Scale approximate*: 1 *inch* = 40 *miles*

LONG ARROW, represents axis of storm track. Figures, 1, 2, 3, etc. encircled by small arrows, mark positions of storm center corresponding to reference points on the track similarly numbered.

BROKEN LINES represent ship's track.

*The upper track* is computed from data in the ship's log.

*The lower track* results from the application of a current (S. 52° W. 3 knots per hour) to all the courses of the upper track.

*Small circles* numbered, 1, 2, 3, etc mark ship's position for each point of reference, and those on the lower track referred to corresponding numbers on the storm-track, show approximately bearing and distance of center.

SMALL ARROWS, indicate true direction of wind for each point of reference.

CURVED ARROWS near islands show deflection of lower currents of air, caused by contact with high land.

FIGURES on the land and in brackets near it indicate height of the land in feet.

Fig. 2. *Scale approximate*: 1 *inch* = 80 *miles*.

LONG CURVED ARROWS, bound the storm-disk and indicate cyclonic movement of winds within it.

LONG STRAIGHT ARROW represents axis of storm-track.

HULKS: numbered, 1, 2, 3, etc. show positions of ship in the storm-disk corresponding to reference points on the ship's track and storm track (Fig. 1,) similarly numbered, and are plotted by bearing and distance from center.

STRAIGHT ARROWS, pointing to hulks, indicate true or actual direction of winds.

*Short curved arrows* show the corresponding cyclone winds.

LETTERS above arrows show the direction, and figures in brackets near them, the force (Beaufort's scale,) of the winds.

*Letters and figures* below the arrows show state of barometer and thermometer as observed on board ship.

THE ARROW at hulk, 12, applies equally to hulks, 11 and 12, as also do the forces of the wind and the barometer readings, in the order in which they are marked on the arrow.

Fig. 3. *Represents Centripetal motion of winds.*

BLACK HULKS: a....a, b & c show in each case the true or cyclonic positions, and a′ b′ & c′ the corresponding centripetal or false positions of the ship in the storm-disk.

Fig. 4. *A cyclone near Réunion island South Indian Ocean*

LONG ARROW, axis of storm-track.

SMALL CIRCLES projected on the arrow mark positions of center corresponding to times marked abreast.

BROKEN AND DOTTED·LINES represent the tracks of eleven vessels, as follows:

1. *Angèle.*
2. *Somme.*
3. *Alfred.*
4. *Victorine.*
5. *Lise et Berthe.*
6. *Ville de St. Denis.*
7. *Pacifique*
8. *Washington.*
9. *Eugène et Amélie.*
10. *Veaune.*
11. *Ange gardien.*

Plate. II.

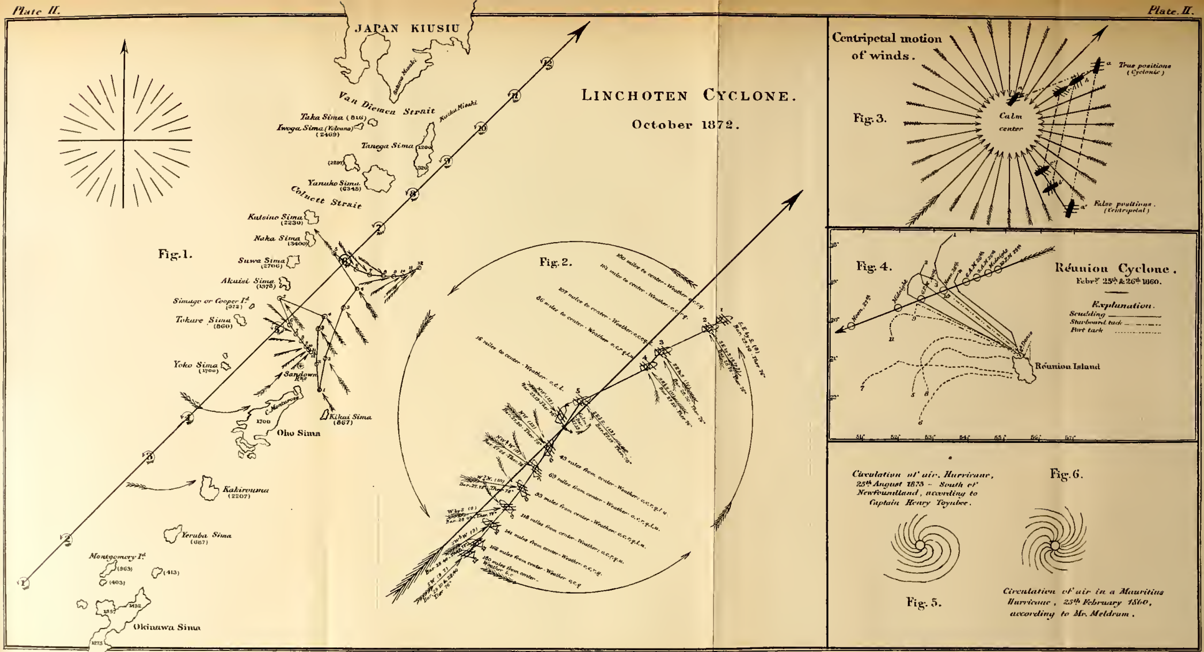

JAPAN KIUSIU
LINCHOTEN CYCLONE.
October 1872.
Fig. 1.
Van Diemen Strait
Taka Sima (816)
Iwoga Sima (Volcano) (2469)
Tanega Sima
Yanuko Sima (6345)
Colnett Strait
Kutsino Sima (2230)
Naka Sima (3400)
Suwa Sima (2700)
Akuisi Sima (1978)
Simago or Cooper Id. (372)
Tokare Sima (860)
Yoko Sima (1700)
Sandown Rks.
Kikai Sima (867)
Oho Sima
Kakirouma (2207)
Yeruba Sima (687)
Montgomery Id.
Okinawa Sima
Fig. 2.
Fig. 3.
Centripetal motion of winds.
Calm center
True positions (Cyclonic)
False positions (Centripetal)
Fig. 4.
Réunion Cyclone.
Febry. 25th & 26th 1860.
Explanation.
Scudding
Starboard tack
Port tack
Réunion Island
Fig. 5.
Circulation of air, Hurricane, 25th August 1873 – South of Newfoundland, according to Captain Henry Toynbee.
Fig. 6.
Circulation of air in a Mauritius Hurricane, 25th February 1860, according to Mr. Meldrum.

Fig.
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hours more he ran S.E. $\frac{3}{4}$ S., twenty-six miles (Pt. 4.) At this point the wind had increased to a fresh gale, blowing from N.N.E. $\frac{3}{4}$ E., barometer had fallen to 29.12 in. and the weather assumed a very threatening appearance, overcast, with heavy squalls, rain and lightning. Still believing himself in the left semicircle, (notwithstanding everything indicated the contrary), but finding that he was nearing the center, he concluded to bring the ship by the wind, and await the opportune moment for resuming his course. The ship was accordingly put under close reefs and storm canvas, on the port tack head-reaching, and was so kept about one and a half hours, when at noon, on the 12th, (Pt. 5), the wind had increased to a strong gale (10) barometer, fallen to 29.02 in., wind changed to N.E. $\frac{1}{2}$ N. and the weather steadily growing worse, the captain evidently began to think that he was approaching the center rapidly, and his hopes of fair westerly and south-westerly winds, died away with the first gleam of an idea that he might have been mistaken as to the course of the storm. Be that as it may, he wore ship and hove her to on the starboard tack. He drifted in this way during three and a half hours to (Pt. 6) where the wind, blowing furiously, had changed to East, but the barometer, during the interval, had remained steady. During five hours more the wind continued blowing with unabated force, gradually veering to the southward, and at the end of this interval was S.E. by E. $\frac{3}{4}$ E. and the barometer had gone up to 29.23 in. (Pt. 7). During the following thirteen and a half hours of this storm, the barometer rose gradually to 29.58 in. and the wind, veering slowly, was at about 10.00 A. M., September 13th, S.E. $\frac{1}{2}$ E. blowing a fresh gale, and rapidly moderating. At this time the lightning had entirely ceased and the general appearance of the weather very much improved (Pt. 9.) Sail was now made on the ship and during the remaining eight and one half hours within the stormdisk she made good a course S.E. $\frac{3}{4}$ E. fifty-six miles, and about 6.30 P. M. on the 13th September she passed out of the storm-circle (Pt. 11) the wind being S.E., blowing a fresh breeze, and the barometer at 29.90 in. The thermometer ranged from 71° to 79° being 78° at the point of entrance into the stormdisk, 79° at the point nearest the center and 71° at the point of leaving the storm-circle.

## LINCHOTEN CYCLONE.

On the diagram marked Linchoten, Plate II, Fig. 1, I have plotted the track of the *Francis Henty* (bark) of Melbourne, as it appears from

a careful computation of the data in her log-book, and a second track which results from the application of a current to all the courses. Fig. 2. shows the position of the ship in the storm circle, plotted by bearing and distance from the center.

The rate of the storm's progressive movement was ascertained to be about sixteen miles an hour. By working up the data found in the log-book of the british bark Hilda which passed through the same storm, I was enabled to locate the center thirty-five hours after it passed the *Francis Henty*, having traveled during the interval about five hundred and sixty miles north-eastwardly.

With these figures and the *Francis Henty's* log, I have computed the diameter of the storm to be about three hundred and sixty miles ; and the diagram is accordingly constructed on the basis of the above figures.

The Colonial bark *Francis Henty* of Melbourne, commanded by Mr. W. T. Ouayle, left the Saddles, off the mouth of the Yangtze river, China, on the 4th October, 1872, bound for Yokohama, but owing to contrary wind she was unable to fetch the Strait of Van Diemen, and so was obliged to bear up for Colnett strait. Before reaching this point, however, the captain discovered indications of a cyclone to the southward, and decided to remain on the western side of the islands, and await the result of the coming gale. His barometer was low and indicated great agitation in the atmosphere by a constant oscillation of the mercury in the tube, and this considered, together with a heavy cross-swell, occasional flashes of lightning, and a general threatening appearance of the weather, left little doubt that a storm was not far distant. On the morning of the 8th October, being then in the vicinity of Yoko sima island, the barometer rose 0.20 in. from 29.30 in. to 29.50 in. and this circumstance threw the captain off his guard; he thought the danger was all over, and, believing the storm was passing away from him, he took advantage of a slant, to pass through close hauled on the port tack between the islands of Tokare sima and Yoko sima ; but the wind hauling to the eastward headed him off, and when he had reached a point about eight and a half miles N.E. ¾ E. from cape Monturose, it was E.S.E. still hauling to the southward and rapidly increasing in force, blowing at the time a strong breeze. The vessel was here put on the starboard tack, and kept free with a view to repass to the westward of the islands, as it was now evident that the storm was approaching, notwithstanding the rise in the barometer. While running to the northward the barometer still kept rising,

and actually rose 0.20 in. more, viz. from 29.50 in. to 29.70 in., but the wind at the same time continued to increase in force, and the clouds came rushing on so fast and thick, that the question of passing through the chain of islands to the westward became a very doubtful manœuvre, attended, if attempted, with incalculable risk, considering the force of the gale blowing, and the impossibility of seeing far enough ahead to avoid an island or a rock, should one happen to be in the way. The vessel was therefore hauled up on a course nearly parallel to the trend of the islands, and sail reduced. The barometer soon ceased to puzzle the captain; it commenced to fall much more rapidly than it had risen, and that and the wind told the whole truth. The storm was coming direct for the ship, the latter having no possible way of escape.

The facts, as they occurred during this storm, are as follows:—At 7 P. M., October 8th, we find the *Francis Henty* at a point N.E. ¾ E. eight and one-half miles from cape Monturose, the N.E. point of the island of Oho sima (Pt. 1.). From this point she steered to the northward and eastward for Colnett strait; running with the wind from S.E. by S. blowing a moderate gale; the weather was overcast, squally and rainy, and the sea rough. During a run of two hours, she made good a course N. by E. ¼ E. * sixteen miles (Pt. 2). The barometer, during this interval, had fallen 1.05 in. from 29.70 in. to 28.65 in. and the wind had increased to a fresh gale (9). The clouds also had descended to the water surface in a solid wall of deep black, and enveloped the ship in a dense mist: this added to the natural obscurity of the night, rendered the darkness intense, which was relieved only by occasional flashes of lightning. The idea of passing to the westward of the islands was abandoned, and the ship was hauled off on a course nearly parallel to the trend of the islands, under double reefs and reefed courses. She ran in this way during an interval of three and three fourths hours, and made good a course N.N.E. twenty-seven and a half miles; at this point (Pt. 3) the wind was S.E. ¾ S., having increased to a strong gale, (10) and the barometer had fallen 0.35 in. to 28.30 in. The vessel was then put under close reefs, and the mainsail furled; and under two close-reefed topsails, foresail and lower staysails, she was kept a good full, with the yards braced well in, in order to gain ground if possible to the eastward. This heavy press of canvas was kept on until a violent gust split and carried away all her square sails, broke the mainyard short off in the slings, and sprung the foreyard. In this condi-

* This as well as the following courses and distances, is the true course and distance, resulting from computation of the data in the log.

tion she was brought to, under storm staysails, on the starboard tack, having made good a course N.E. ¼ N. twelve miles (Pt. 4.) while trying to make easting and, if possible, distance the center, which, there had been no doubt when the manœuvre was commenced, was coming direct for the ship, and hence these desperate efforts to avoid it. At this point the wind was S.E. ½ S., blowing a terrific gale (11) barometer 27.50 in. (having fallen 0.80 in. in one and three-fourths hours) and the condition of the weather beyond description. To use the captain's own expression in speaking of the lightning, he said: "It came tumbling down on all sides in vertical columns of vivid green," and in trying to convey to me a general idea of the surroundings at the time, he added in substance the following: "while laying to and trying to clear away the wreck as much as possible, the sea, though running high, did not break, owing to the pressure of the wind upon it. The wind steadily increased and the gusts became stronger, and more frequent, until it was thought impossible for the wind to blow any harder; and yet it increased and increased again till the noise became deafening. The howling of the wind, the roaring of the waves, and the creaking of hull, spars and rigging was something terrific, added to which, the dreadfully vivid glare of the now almost constant sheet of lightning, rendered the momentary intervals of darkness, the darkest of the dark." To a question as to whether or not he heard any thunder, the Captain answered: "I cannot say, but I don't think any thunder could have been heard above that terrible noise."

The ship had drifted about three and one-half hours in a helpless condition, (enveloped in a dense cloud of rain and spray, driven furiously against and over the ship, the men being lashed on deck), when the captain thought of his barometer, and on examination found it standing at 27.19 in. A few minutes later when he again looked at it, the mercury had fallen out of sight, he did not know how far. The wind at this time was S.E. ¼ S., and, almost immediately after examining the barometer the second time, he felt one terrific gust strike the ship, under the pressure of which she listed over until her yard-arms touched the water, and so remained for about a quarter hour, when the wind suddenly lulled, and during an interval of from five to ten minutes, gradually grew weaker, until eventually it died away entirely; and, in the place where but a few moments before, nature had raged in all her wildest furies, reigned at this time (6.30 A. M., Oct. 9th,) an absolute calm. The ship had drifted at an estimated rate of five and one-half knots an hour, and I have therefore allowed, N.W. ¾ N., twen-

ty-two miles of drift for the four hours since she was hove to—(Pt. 5). After the ship had passed into the calm space, and the noise of the wind and sea had somewhat subsided, it was discovered, that the fore and main top-gallant masts and the mizzen top-mast had all been carried away, and shortly after a heavy sea came over forward, which, in its passage, carried the jib-boom with it.

Although the wind had ceased, the danger was by no means lessened, for the sea ran so high, and with such fearful irregularity, that the probability of foundering was very great. While tossing about in this way she shipped seas from all directions, and stove in her bulwarks on both sides between the fore-castle and poop; breaking several of the stanchions just above the covering board, and as if to fill the cup of bitterness to the brim, in these moments of anxiety and dread, the main-hatch was partly blown out by the expansion of the air below, which, having a greater specific gravity than that on the outside, and exerting an outside pressure of more than one pound to the square inch, (the barometer having fallen two and a-half inches since entering the stormdisk) naturally sought to establish an equilibrium through the weakest part of the ship.

While trying to secure the hatch to prevent the water from rushing down into the ship's hold, the second mate, who was at that work, was washed overboard by a sea coming over the starboard beam, and was actually tossed back again, by another which came on board over the port-side. I mention this circumstance to show how irregular the sea must have been. The captain described the seas in the calm center, as so many church steeples, rising, tottering, and falling in the wildest confusion.

To a question as to how the clouds or atmosphere appeared in the center he answered: "The central space was filled by a thick, gray haze or fog, through which, at intervals, I saw blue sky. The rain had ceased, but lightning, in a less degree, still continued." But to return to the ship; we find her tossing about in the center of a cyclone, perfectly unmanageable, with her top-gallant-masts, mizzen-top-mast, head-booms and mainyard gone, fore-yard sprung, and nearly all her sails blown away, with the certainty of having to encounter another part of the storm equally as violent as the one she had just passed through. In order to avoid being driven against a heavy sea on the lee quarter, when the wind, as he expected, should come out from N.W., the captain decided to put the ship on the port tack; but how to accomplish this without any sails or wind was the question. He rightly conjectur-

ed, however, that a few light puffs would probably precede the strong blast on the other side of the center, and thought he would have time to point the ship's head in the right direction if he had but some sail forward. He did not dare open his sail-lockers for fear of swamping or filling the ship with water, and he had nothing but a storm staysail left forward with which to attempt to wear, or rather to point the ship's head. A three cornered lower-studding-sail, lashed under the forecastle deck was, however, thought of at this moment, and it was quickly got out and secured to the fore-yard on the starboard yard-arm from the slings out, keeping the sheet on deck, made fast to the bitts near the mast. By these means he managed to point the ship's head to the N.E. during some little gusts of wind on the rear edge of the calm center, and when the wind came out in force she received it on the port side. The wind came out from N.W. with such force that she was again thrown down, nearly on her beam-ends. Having lost, however, her upper spars, she righted a little, after the first tremendous gust had passed, but still, during the next half hour, the wind forced her over so that she was drifting with her lee scuppers under water, against a sea, which, under the impetus it had received from the S.E. wind in the first part of the stormdisk, was still running with considerable force from that direction. I will not attempt to describe the horrors of that half hour, during which it was expected every moment that the deck would be crushed in by the sea; and this would probably have occurred if the bulwarks had not previously been carried away; as it was, the sea made a clean breach over the vessel without stop or hindrance. The sea, however, soon yielded to the tremendous force of the wind and continued during the heaviest blow comparatively smooth. She drifted in this way for two and a half hours about fourteen miles S.E. ¾ E., (Pt. 6) the wind blowing a hurricane from N.W. under the same circumstances of weather as already described on the other side of the center, with the single exception of it being day 9.30 A. M. instead of night, as was the case before. About this time the wind moderated a little and the ship righted, the barometer was examined and registered 27.20 in. The sea commenced to rise with the abatement of the wind. During the next one and a half hours the wind blew with an estimated force of (11) and had veered to N.W. by W. ¼ W., barometer went up to 27.25 in. and the ship drifted E.S.E. ¼ E., seven miles (Pt. 7). The story of this storm, at least that part which properly comes within the scope of this paper, is now told; and the only remaining feature to which I will call attention is the veering of the

wind to the southward, as the ship approaches the island of Oho sima. Thus at (Pt. 8) wind is W. $\frac{3}{4}$ N. blowing a strong gale (10) barometer 27.75 in. and ship has made seven miles E. $\frac{3}{4}$ S. At (Pt. 9) the wind is W.S.W. $\frac{3}{4}$ W., blowing a fresh gale (9) barometer 28.00 in. and ship has made six miles E. $\frac{1}{4}$ N. At (Pt. 10) the wind is S.W. by W., barometer 28.40 in. and ship has made five miles E.N.E. $\frac{3}{4}$ E. At (Pt. 11) the wind is S.W., blowing a moderate gale (8) barometer 29.10 in. and the ship has made five miles N.E. by E. $\frac{3}{4}$ E., weather clearing. At (Pt. 12) the wind is S.W., blowing a fresh breeze (7) barometer 29. 40 in. and ship has made five miles N.E. $\frac{3}{4}$ E. At this time 6.30 P. M., Oct. 9th, she was found to be about seven miles N.N.E. from Sandown rocks, after having passed through the most violent storm that I have ever heard an eye-witness describe, and, after an interval of twenty-three and a half hours of sailing and drifting, she found herself only nineteen miles from the point where she started the previous evening at seven. I will here leave the *Francis Henty* to make the best of her way to Yokohama.

Before proceeding farther I will briefly explain the two tracks shown on this diagram. The upper track is the one resulting from the plotting of courses and distances sailed, and the measured and estimated drift as per ship's log ; but the ship, at the end of the storm, was found seventy-one miles S. 52° W. from the point where the log placed her, and as I have no means of accounting for this difference, I have assumed that a uniform current of three knots per hour, setting S. 52° W., affected the course of the ship during her passage through the stormdisk, and the lower track, resulting from the application of this current to all the courses, is approximately the one over which the ship passed. As, however, the major part of this surface set must have been produced by the storm, the ship was probably, not so much affected by it in the beginning as in the latter part, and, her true track lies somewhere between the two here plotted.

It is a significant fact that the *Francis Henty* was set to the S. W. rapidly by the same current after the storm was over.

It is not unusual to find, what is known as the storm wave setting strongly in the direction of the course of the storm; but it will be observed that this current came from nearly an opposite point, and I am at a loss to account for it, except upon the assumption that the surface waters were driven furiously against the islands by the S.E. winds, and not finding ready means of escape through the passages between them, were turned off to the southward, through the wide and clear passage

between the island of Oho sima and the islands to the westward.

Review.—I will now briefly review the two last cases, and examine the evidence before us; my object being to show that the wind within the stormdisk of a cyclone, blows, as the word implies, in a sort of spiral curve resembling the coil of a snake, which for all practical purposes may be considered a circle. In other words, that the winds blow in circles round a common center; subject, however, to certain modifications growing out of the contact with land; the extremes of which I believe are to be found in the two cases here represented, for which reason I have selected them as the subject of my paper; and I regard them, whether considered separately or together, as typical of the cyclone with all its variations.

In the first case, we have the Formosa cyclone moving W. by S. and coming in contact during its course with the south end of Formosa island. We notice that the long arrows which indicate the direction of the wind as registered on board the *Argyleshire* come from a point northward of that shown by the short arrows, which represent the wind as it ought to blow according to the cyclone theory, until the ship comes near a perpendicular, from the center, raised on the line of its axis (Pt. 6) after passing which we find the long arrows coming from a direction south of that indicated by the short arrows (Pt. 7) and, again as the ship approaches the edge of the eastern or rear portion of the stormdisk, the difference in direction of the arrows grows gradually less, until at (Pt. 10) the coincidence is nearly perfect. Let us notice also in this connection that at (Pt. 9) a perpendicular from the center, falls westward of the south point of Formosa, and that the influence of the land upon the wind grows gradually less as the center passes westward. Now if we consider a cyclone travelling eight and a half miles an hour and coming in contact suddenly with a mass of high lands, such as we see on the south end of Formosa, where a mountain range runs parallel with the coast and rising from nine thousand to eleven thousand feet above the sea, and several peaks south of it ranging in height from two thousand to nine thousand feet, it is but reasonable to suppose, that something must give way, and that something is the wind. The first effect is to check the course of that part of the stormdisk actually in contact with the land, and next, the wind in the struggle for liberty naturally turns toward the side where it meets with the least resistance, viz., the center of the storm.

While this is going on in front, the rear part of the storm is partly checked in its turn, but still pressing forward, and the result is a dis-

tortion of the stormdisk. The currents of air, instead of passing over the arc of a circle, assume the form of an ellipse more or less irregular according to the nature of the obstruction and the speed with which the storm is moving. All these things considered in connection with the Formosa cyclone I believe will satisfy every question in the problem. As will be seen by the wind arrows on the diagram, while the ship was to the westward of the axis or longest diameter of the ellipse, she had the wind from some direction northward of the cyclone point*, and that after passing to the eastward of that line the wind actually blew from some point southward of the cyclone point, which is in perfect accord with the above expressed idea of the distortion of the stormdisk. We also notice that after the center has passed the south point of Formosa, and in proportion as it passes farther to the westward of that point, the winds gradually resume their normal direction, (the circular course) and at (Pt. 10) the coincidence of the two arrows is nearly perfect; a fact which would seem to indicate that, had there been no obstruction the wind would have blown in circles throughout the entire area of the storm.

This storm presents another feature of interest not often met with, and if we suppose a ship caught in this storm anywhere within fifty or sixty miles of the south point of the island, on the east coast of Formosa and within the limits of the converging currents, we have the case before us. A vessel so situated would have the wind from N.N.E. and locate the center at the E.S.E. which would at first be true; but this bearing according to the wind would remain the same, during the passage of at least one half the stormdisk over the ship, and the barometer falling also, because the center is gradually coming nearer, would indicate, that the storm was actually coming straight towards her.

This is one of the cases where the judgment of the commander may save his ship, and where a want of judgment and nerve will certainly lead to destruction. He has, it is true, no means of determining the course of the storm, but, he knows that its center is to the eastward of the island, and by examination of his chart he will see at once, that whether the course of the storm is westwardly or northwardly, the wind along the coast of that high land would equally be from N.N.E. or parallel to the coast. In his position he is on a lee shore if the storm is travelling westward, and he must run for the south point of

* The point from which according to the rotary theory the wind ought to blow.

the island until clear of it to the southward. If to the contrary the storm is coming straight for him, as the wind and the barometer indicate, his only safety then lies in scudding. Even if the course of the storm is such as to strike some point on the coast south of him he must still run, with the hope of crossing its track ere the dangerous vicinity of the center has advanced far enough to do him any serious harm; and if the course of the storm forms anything less than a right angle with the coast line he may reasonably expect to accomplish this; for there is scarcely any danger of the entire storm leaping over mountains eleven thousand feet high, if it has room to turn off to the eastward, which it would probably do as soon as the currents in front had banked up against the coast sufficiently to produce a pressure in that direction. In either case his chances for escaping the center are good, and once south of the island, there is plenty of sea room to run out of the storm or heave to and drift as might appear best. If however the course of the storm is westward as in the present case, the question becomes more serious; but it is a question between life and death, the center of a cyclone and a lee shore; and must be decided quickly. To remain hove to in such a position is certain destruction; for, after the center has passed westward of the island, the wind will gradually curve less and less until eventually it strikes the broadside of the coast at a right angle and leaps over the land. By squaring away in time, he may reach the south point of Formosa, ere the center reaches there, but at any rate he must take his chances, and prepare to meet the worst part of the storm in preference to the rocky shores of the island. The chances, however, are all in his favor by scudding, and all against him by heaving to; in the latter case he will certainly bring up on the rocks, in the former he may run into the center; but we know that ships have passed through the center, as did the *Francis Henty* through one of the most violent storms on record, and come out comparatively all right. The chances are also, and in his favor, that the center of the storm will not pass near enough to the south point of Formosa to bring him into dangerous proximity with it, as the high land would in all probability turn it off to the southward. Once south of the island and hove to on the starboard tack the ship would be in a comparatively safe position. This course of action, however, applies only to high land and a bold coast. If, on the contrary, the land was low and the water shallow for some distance off shore, as on some parts of our own coast, it is a question whether or not, if the storm was moving westward, the safety of the ship would be insured

by scudding, or even if such a course would be justifiable; and I am of opinion that it would not. In that case a ship hove to on the starboard tack would be safe until it was found, by her shoaling the water, that she was drifting into dangerous proximity with the land, in which case the last resort would be to drop the heaviest anchor and pay out one hundred and fifty fathoms of cable or more if necessary on the same anchor, and then reduce the surface aloft by sending down spars &c., having a second and third anchor ready, in case of accident to the first or second.

With respect to the Linschoten cyclone, the problem of manœuvre is more simple. The captain in this case did all that could be done under the circumstances to avoid the center, with the single exception of passing through the chain of islands to the eastward, when a proper interpretation of the action of the barometer and careful study of the condition of the weather, would decidedly have led the discreet navigator to the adoption of a contrary course; for it is now a pretty well established fact, that, not unfrequently, the atmosphere on the border of a cyclone is banked up in front by a temporary resistance to the forward movement of the storm, and thus produces a greater pressure on the barometer, as is seen in the case before us. The barometer here fell one inch in less than two hours after entering the storm disk, and at no time during the ship's presence within its limits did so great a fall occur in the same length of time. The greatest fall registered afterwards was 0.8 inch in one and three quarters hours, from 28.30 inches to 27.50 inches. During the next four hours the barometer fell 0.31 inch from 27.50 to 27.19 inches, but it will be remembered that this was the lowest reading, obtained about half an hour before entering the calm center, and that a few minutes after, when the captain again examined the barometer, the mercury had fallen out of sight, we do not know how far; and I have therefore taken the lowest reading as the minimum pressure. It is, however, quite possible that the barometer in this case fell below 27.00 inches because in the Yokohama cyclone, when near the center the barometer fell 0.15 inch in fifteen minutes and supposing the *Francis Henty's* barometer to have fallen at the same rate (and the sudden disappearance of the mercury would seem to indicate that it did) during the half hour following the last reading, it would have fallen 0.30 inch and instead of 29.19 inches would have read 26.89 inches. Assuming this to be true, the *Francis Henty* exhibits the greatest barometer-fall on record, although not the lowest recorded pressure at the

water surface. The greatest recorded fall of the barometer, occurs in the case of the brig *Gazelle* in the China sea, 1849,=2.80 inches from 29.80 inches to 27.00 inches, and the minimum pressure recorded on ship board is given in Piddington's Hornbook, page 264, as 26.30 inches on board the East-India-man *Duke of York* off Kedgeree, river Ganges 1833. But to return to the case in point, the *Francis Henty,* we follow her through the first half of the storm and find that the wind blows during the whole interval, from a direction between S. E. by S. and S.E. ¼ S. which, is in strict accordance with the cyclone theory where there is no land to divert its course; and after passing through the center, we also find that the first violent blast is from the N.W., which likewise, is a confirmation of the idea of circular motion knowing that the storm moves N.E. We further notice, that in proportion as the vessel approaches the island of Oho sima, the wind gradually takes a more northerly course in other words, veers to the southward, drawing up the channel between Oho sima and the islands to the westward. This is simply another case of the incurving of the wind already explained in the case of the Formosa cyclone. The only difference between the two being, that in the present case it occurs in the rear portion of the storm disk, while in the other it took place in the fore part of the same.

I have mentioned before, that I selected these two cyclones (the Formosa and the Linchoten) as the subject of my paper, because of the embodiment in them, of nearly the extreme variations of the wind from the cyclone point, and because if dissected and considered in part only there will be found in each of these storms, a sector that would appear to contain the elements of a law upon which another theory (which, by the way, has a great many advocates) is based. I refer to the centripetal or inblowing theory of which Professor Espy of Philadelphia may be considered the author, and which embodies substantially the conclusions arrived at by Professor Brandes of Germany as heretofore mentioned; and I doubt not that an advocate of Mr. Espy's theory, had he been on the spot, would have found ample data in the facts as they occurred to prove it.

Before proceeding farther I would state my opinion, that great ocean storms known as cyclones, &c., are separate and distinct phenomena, created, existing and dying in accordance with certain natural laws, for which no absolute solution has as yet been found; and further, that they have no relation to or connection with the ordinary gales, which do not possess the same characteristics and ought not therefore to be

classed in the same category. They are met with in particular localities, and generally at particular seasons. I do not mean to say that a cyclone may not be met with anywhere or at any season, but as a rule, they prevail during particular periods of the year, and are more frequently met with in some seas than in others. The China seas Indian ocean and North Atlantic, appear to be much more frequented by these storms than the South Atlantic or Pacific. They are sometimes met with in the Mediterranean, but rarely, if ever, in the North sea or Baltic, while at the same time gales of wind are common and often very violent in both of the last named seas.

Now it appears to me that some of the modern writers, who condemn the cyclone theory make no distinction between the great ocean storms and ordinary gales, and besides, base their opinions on observation, chiefly made on shore and on theories deduced therefrom; and while these theories are doubtless the result of much scientific research, of great personal activity and labor and of faithful and honest investigation in search of truth, and also, while the course of reasoning pursued manifests a high order of talent on the part of the writers; yet if these theories do not accord with what actually takes place in a storm at sea, they are worse than useless, they are dangerous to the navigator.

The better to demonstrate this I will briefly compare the centripetal or inblowing theory of Brandes and Espy with the cyclone theory of Redfield and Reid, and take as an example the *Francis Henty* here represented in the storm disk, her track through which we know and have therefore nothing to suppose. We find her lying in the N.E. quadrant of the storm with the center bearing S.W. by W. (Plate II, Fig. 3. *a*) and having the wind S.E. by S. Now, according to the centripetal theory with the wind S.E. by S. the center bears N.W. by N.; in other words the ship's position in the storm circle is always on the compass point from which the wind blows and the center always dead to leeward, (Fig. 3. *a'*). Being on the outside or near the edge of the stormdisk and having noticed as did the captain of the *Francis Henty* the storm approach from the southward, the commander assumes that it is moving northward or north-eastward, and with the center bearing as he believes N.W. by N., he sees a good opportunity to run along with it, and so shapes his course N. by E. ¼ E., but after running for a while he finds his barometer falling and concludes that his course brings him towards the line of the storm track and to avoid this he hauls off to the eastward, first, N.N.E., and then N.E. ¼ N., but ere

long, the storm having travelled sixteen miles an hour, while the ship has made only seven or eight knots, the wind has increased to such an extent that all his sails blow away, and he is left in the condition of the *Francis Henty*, and in the same place, from which there is no escape, and so he meets her fate. (Fig. 3. *a* center.) This is what he would do in mid-ocean with plenty of room to manœuvre on the principle of the centripetal theory. But suppose we reverse the case, and that instead of assuming that the storm is travelling northward, he heaves his ship to, to ascertain its movement, and still finds the wind S.E. by S., he places the center bearing N.W. by N. as before. After having laid to for a time sufficient in his judgment to bring about a change of wind, and having experienced none, he looks at his barometer and discovers a great fall in the mercury, he naturally concludes that the storm is moving directly towards him and so decides to get out of its way. Having the center as he supposes bearing N.W. by N. and the storm moving S.E. by S. he finds that the course which will take him most directly away from the center is S.W. by W., and accordingly he fills away on the port tack (Fig. 3. *b* & *b′*) and runs along with the wind abeam, until his sails blow away as before and he is left in the same place at the mercy of the storm. But if instead of the port tack he fills away on the starboard tack, (Fig. 3. *c* & *c′*), as he can do either with the wind S.E. by S.) and stands N.E. by E. it is only a question of a few hours more before the storm will overtake him.

By the above, and by thousands of other cases that might be cited, it is seen that the centripetal theory of the motion of the wind in storms, is not borne out by facts as they occur at sea, and also, that the means which according to that principle should be adopted to escape the center, simply lead a vessel into it; for the reason, that by the assumption that the winds blow in straight lines towards the center, that point is located 90° to the right of its true position in the northern hemisphere, and 90° to the left of its true position, in the southern hemisphere; and yet Professor Blasius says that this theory has more of the germs of truth in it, than the cyclone theory. But the shortest refutation of the centripetal, or any other theory supposing the winds blowing in straight lines towards a point or a line of minimum atmospheric pressures is, the fact, that no ship has ever run into the center of a storm or cyclone by running before the wind, except perhaps, in the vicinity of land when the stormdisk was distorted by contact with it, or when near high land under the influence of converging currents of air it was done purposely to avoid a greater evil, and finally, by trying to cross the

storm track under circumstances when such an attempt was manifestly improper and the thing impossible.

The Centripetal and Cyclone theories, however, have some things in common; for instance, the changes of the wind occur in the same manner on both sides of the axis or line of forward movement; and according to both theories a vessel may run before the wind along with the storm in the direction of its course; in the former case in its rear on the line of its axis, and in the latter case abreast of the center on a tangent parallel to its course.

These very similarities constitute a real danger to the seaman, who, having read and perhaps studied the writings of anti-cyclonists, that is of the writers above referred to who condemn the cyclone theory, has begun to doubt the truth of the latter, and finding some things in accord in both, (the cyclone and the centripetal theories) is apt to conclude that the centripetal is but the cyclone theory revised and presented in its true aspect; and although the fallacy of the former is abundantly proved by experience, yet it cannot be denied, that, to the purely theoretical student, it must appear more plausible and more logical than the cyclone theory; inasmuch as it is less difficult to account for the centripetal than the rotary motion of currents of air seeking to arrive at a point of minimum pressure in the center of a storm.

Mr. Redfield and his followers or co-workers have however presented us with a true problem and furnished us a formula for its solution, and the man who at this day runs into the center of a cyclone when he has room to avoid it has no one but himself to blame.

With reference to the case already mentioned as being on record in a work entitled "Storms; their nature classification and laws"—by Professor Blasius, page 241, and which Mr. Meldrum is there represented as citing in support of his theory of inblowing currents in great ocean storms, I have translated from a work entitled: "Etude sur les Ouragans de l'hemisphére Austral," second edition by M. Bridet Capitaine de Fregate, etc. etc. [published under the auspices of the Minister of Marine, issued from the Depot des Cartes et Plans de la Marine. Paris and numbered 465] the following account of the storm of the twenty-sixth of February 1860. Captain Bridet was at the time Captain of the port at Réunion and his account of the storm is from personal observation, the reports of commanders of vessels and from extracts from the logs of forty-two vessels that were involved in the storm.

Thus; on page four he says: "My functions as Captain of the port

at Réunion, have enabled me to consult the logs of forty-two vessels, which, either left the roads of the colony, or were in its vicinity at sea; all having suffered more or less during the storm of February, 1860. By data found in these logs I have been able to fix the position of these vessels at noon February twenty-sixth, as well as the winds experienced by them at the same time." * * * * * * * *

On page 115 and following pages to page 137, I find the following account, which I have somewhat abridged in the translation, to suit the purposes of this paper.

"On February 25th 1860 at 9 A. M. the vessels at anchor in the roadstead of St. Denis, received orders from the port authorities to put springs on their cables, slip and stand to sea. A continually falling barometer, a heavy swell (bore) and squalls from the S.E. in short every appearance of the weather indicating a storm approaching.

The vessels in other quarters had been under way for several days, so that, at this moment, all the roadsteads of the colony were abandoned. In getting underway from St. Denis the vessels stood out on the starboard tack close hauled; but the rain, which fell abundantly, soon shut them out from view of some of their commanders who stood on the shore watching the manœuvres of their vessels with a very natural anxiety. What they (the vèssels) did after this time, and the perils which they encountered has been learned from the logs or the reports of each one as follows:

The wind was steady from S.E., which indicated that the center of the storm would not pass far from Réunion, and consequently that the vessels at sea would find themselves nearly in its track; therefore, several of the captains better informed than the rest, or perhaps, having more confidence in the cyclonic theory of storms, did not hesitate to put their ships before the wind in order to cross the storm track in front of the center and take refuge in the manageable semi-circle. Four of them *l'Angele, la Somme, l'Alfred* (colonial) and *la Victorine,* adopted this course. (Plate II Fig. 4.)

L'*Angele* (Captain Barraud) from Saint Lew on the 22nd of February bound for La Possession was the first to decide on this course, and the captain in his report expresses himself as follows: On the 25th of February at ten A. M. being about fifteen miles N.N.W. of cape Bernard on the starboard tack, seeing the barometer at 747$^{mm}$ (29.40 in) and still falling, the appearance of the weather bad and getting worse, and the wind steady from S.E. I judged that I was on the track of the advancing storm. The sea was not yet very heavy and I decided to

scud, according to the storm theory, and filled away without any accident. I ran N.W. under my close reefed maintopsail.* At 4 P. M. the sea had increased considerably, the rain fell in torrents, and the violence of the wind was much greater. I was then about seventy miles N.W. of St. Denis, and still continued my course under the same sail. My vessel being only half loaded behaved perfectly well in this way."

At 8 P. M., barometer had reached 744$^{mm}$ (29.291 inches) below which point it did not fall.

From this moment the wind and sea commenced to moderate, but I nevertheless continued my course.

Midnight 26th February (25th & 26th) the wind hauled to South, and during the night to S.W. and west, moderating very much. I followed the direction of the wind by scudding, until 10 A. M. on the 26th, at which time, finding myself at a safe distance from the center, I brought the ship to on the starboard tack, with the wind at west; barometer 747$^{mm}$(29.40 inches.) The wind was still strong, but the sea was less heavy and the vessel did not labor much.

The vessel was kept hove to on the starboard tack until 6.00 A.M. February 27th, when Captain Barraud, seeing the weather almost entirely re-established, decided to profit by the N.W. wind to regain the anchorage.

This vessel arrived at St. Denis, where she called before proceeding to the roadstead of La Possession, her destination, on the 29th of February, without having suffered damage of any kind, not even the loss of a sail; in short, she was in perfect order and ready to proceed to sea immediately.

It is interesting to remark how firm was the confidence on the part of Captain Barraud in the law of storms, which, as we have seen, was well justified.

At 8 P. M. on the 25th he had scudded for ten hours, during which time the wind and sea had increased, the barometer steadily fallen and the weather grown worse and worse. Under such circumstances, must he not stop? Is the law of storms so well established that one may blindly confide in it? And, finally, ought one to continue running seaward when the weather gets worse in proportion as the land is left in the distance?

"Captain Barraud did not hesitate, he knew very well that he was

* No other sail is mentioned but it may be taken for granted that he had some sail forward also.

nearing the center, but he also knew that the wind would soon change and moderate, and that he would rapidly distance the center, so he continued scudding. At 10.00 P. M., he crossed the line of the axis of the storm track, about eighty-five miles from the center, and after midnight the wind veered to S.W. and west, and moderated as he had anticipated. The vessel scudded twelve hours before crossing the trajectory of the storm, and ran from one hundred and twenty to one hundred and thirty miles before reaching the manageable semicircle.

M. Ansart, Lieutenant de Vaisseau, commanding the corvette *La Somme* had the same confidence in the law of storms and reaped the same benefit. This corvette left St. Denis' roadstead at 9.00 A. M. on the 25th February under sail and steam, and stood out on the starboard tack N.E. carrying storm stay-sails and mizzen. At 2.30 P. M. the commander, seeing the wind blow steadily from S. E. and constantly increasing, the barometer fall and the sea rise higher and higher, thought that by keeping on his course he would pass very near the center, and decided to run off to the N.W. The wind and sea increased steadily during the evening and at midnight the S.E. squalls became intense; barometer had fallen to 744 $^{mm}$ (29.29 in.) the rain fell in torrents without intermission and the ship rolled terribly. Still he continued to scud. At 4.00 A. M. on the 26th the barometer had fallen to 742 $^{mm}$ (29.21 in.) and the wind was S.S.E. At 6.00 A. M., the wind was S.S.W. and it was evident at this time that the ship had crossed the track of the center. Captain Ansart knowing that he was then in the manageable semicircle, hove his ship to on the starboard tack under the storm-mizzen. The squalls had reached their maximum force, and the rain beat with a violence unheard of. About 11.00 A. M., the sea running very high, the ship took a deep pitch, during which a part of the jib was carried away. The barometer continued falling until noon when it reached its lowest stand 740 $^{mm}$ (29.13 in.)

From this moment the barometer began to rise, the sea moderated, and the violence of the wind gradually subsided as it veered to the west and N.W. The following morning, (the 27th) at 8 o'clock, the weather had so far moderated that the corvette set a course for the anchorage at St. Denis where she arrived at noon on the 28th.

From the extract of this Journal (log) it is seen that the corvette, having filled away at 2.30 P. M., did not reach the axis of the storm track until about 3 o'clock the following morning, and that she had run for about twelve and a half hours without any sensible change of wind, and it will be readily admitted that it required a good deal of faith

in the law of storms to persevere in the manœuvre under these circumstances.

The corvette having started to run later than *l'Angele*, must have passed nearer the center in crossing the trajectory, and such in effect is the fact, she having passed sixty-seven miles in front of the center at the time of crossing the line of its axis.

Instead of stopping to heave to at 6.00 A. M., it would have been better to have continued scudding for several hours more; the wind being only at S.W. shows clearly that the center was still drawing nearer."

* * * * * * * * * *

(The storm was travelling W.S.W. 7 miles an hour.)

*L'Alfred* and *La Victorine* were the other two vessels that scudded during this storm. These two fared rather worse than the first two, in consequence of their having started to run at a later hour. *L'Alfred* crossed the track at 10.00 A. M. on the 26th and passed within 45 miles of the center with her barometer marking $736^{mm}$ (28.98 inches) and *La Victorine* crossed the track at 3.00 A. M. on the 26th and passed within 35 miles of the center with her barometer standing at $730^{mm}$ (28.74 inches) but all four arrived safely in the roads after the storm, and without any more serious damage than the loss of a few sails and a couple of boats."

*La Lise-et-Berthe, La Ville de Saint Denis, le Pacifique* and *le Washington* are four vessels which, after getting a good offing, hove to on the port tack and rode out the storm. (The proper thing to do.)

*L'Eugene et Amelie, le Veaune* and *l'Ange Gardien,* are three vessels that kept their starboard tacks aboard and stood out to sea; were thrown in contact with the center and barely escaped total wreck.

*St. Vincent de Paul, le D'Apres* and *le Meunier,* are three vessels that by keeping their starboard tacks aboard were carried into the center, from which they were unable to disengage themselves, and were eventually wrecked on the coast of Madagascar, whither they were carried by the storm.

*L'Albert le Grand, le Bryeron* and *le Courier des Antilles,* are three vessels that disappeared and were never heard from.

Captain Bridet gives the names of twenty-five other vessels that by bad manœuvring, got either into or near the center, and sustained more or less damage, amounting in all to 3,368,882 francs, or $ 660,300.87 with a loss also of eight officers and forty-seven men.

A detailed account of the manœuvring of most of these vessels is

also given, but the above is sufficient for my purpose, as I simply wish to show, that Mr. Blasius, in citing this case as proof of the fallacy of the cyclone theory, is all wrong, and that the newspaper article to which he refers was entirely erroneous.

This case to the contrary, owing to the vast amount of reliable data collected from it, furnishes more conclusive proof of the correctness of the cyclone theory than any other case on record ; inasmuch as the reports in this case cover every part of the stormdisk, and Captain Bridet an educated seaman, interested in the work and on the spot, shows clearly and distinctly, that every Captain who conformed to the rules laid down by Redfield and Reid, escaped unhurt, while those who did not were either totally lost or sustained serious damage; and I will venture to say without depreciation of science, or discourtesy to its devotees, that until the meteorologist shall have solved the whole problem of the storm mystery, and be able to demonstrate satisfactorily the course of the winds within the stormdisk, we must depend on the seaman who comes from the Ocean storm center to tell us how the winds blow there; and, until some better system, based upon a more correct knowledge of the storm area, is devised for avoiding the dangerous center, it will scarcely be prudent to discard the time-honored and tried rules of Redfield, Reid, Dove and Piddington. It is pleasant and profitable to discuss these things on shore, but the officer who finds himself in a storm at sea, ought to have a fixed plan of action, lest by argument and experiment he loses valuable time, perhaps, even ship and crew.

From a careful study of the foregoing examples of actual experience, as well as from a great quantity of similar information, both written and unwritten, most of the latter from persons direct from the stormdisk,* I am convinced, and assert without fear of contradiction or criticism, my belief that the winds within the area of an ocean storm blow

* All of this last matter was collected by myself and carefully worked up, during a term of about two years (1872 to 1874). It included reports of cyclones in the Indian Ocean, Bay of Bengal and China Sea from between fifty and sixty vessels, and contained excellent data of about a dozen separate and distinct storms. I had written it on thin Japanese paper in pencil, and for want of time to reduce it to a smooth copy on proper paper, had so packed it in a trunk when I was about to leave Japan for the United States in 1874. This trunk was dropped overboard alongside a Pacific mail steamer in Yokohama harbor, and some seven or eight hours later when I discovered the accident, my manuscript was reduced to a pulp and utterly illegible. I had however drawn my conclusions from the information it contained, and the opinion expressed in this paper is chiefly based thereon.

in circles or practically so, and that in mid-ocean where there is room to manœuvre, the only way to avoid danger or damage is to conform absolutely to the cyclone rules. But, I am also satisfied that in the vicinity of land the stormdisk is more or less distorted according to the character of the land, the angle of contact * with it, and the rate of forward movement of the storm; and, inasmuch as two of these elements are always uncertain, no rules can be framed for such a case. If however, the angle of contact is small, say less than 20°, although the wind on the side of the storm nearest the land would doubtless draw along the coast, yet the seaward side would probably not be much affected by it, or the winds on that side be sensibly deflected from their normal direction; but if greater than 20°, it may reasonably be expected that the entire stormdisk will be distorted in proportion to the resistance offered by the obstructing medium and the consequent check given to the part of the storm nearest to it, which, of course, depends upon the angle of contact and the velocity of the storm. Except in very extreme cases, where the wind would be deflected six or seven points, the variation of the wind from the cyclone point will probably not exceed four points, and if it be remembered that the effect of the flattening in of a cyclone will always be to bring the center nearer the land than the direction of the wind would seem to indicate, the bearing of the center even in such a case might be estimated pretty closely by making allowance for the deviation of the wind.

But wherever there is a doubt on this point there is a corresponding impossibility of discussing the subject intelligently, and the fate of the ship depends after all upon the judgment of the commander.

The latest work (as far as I know) which pretends to deal with cyclones as a specialty, is published by the British Meteorological office, prepared under the direction of Captain Henry Toynbee, Marine Superintendent, London, England, and treats of the North Atlantic storm of August 1873. It is elaborately illustrated by charts and diagrams, constructed from the data of two hundred and eighty ships' logs and a number of shore observations, extending over the entire area of the North Atlantic. These observations have been reduced as nearly as possible to the moment of 0h. 43m. Greenwich time (P. M.) and so plotted on the charts, one of which is prepared for each day of the month, furnishing at a glance information as to the direction of the wind, atmospheric pressure, temperature, &c.

* By the angle of contact. I mean: The angle formed by the line of the axis of the storm track with the line of the coast.

It supposes the formation of a cyclone in the vicinity of Cape de Verde islands on the 12th August, but no perceptible development of cyclonic winds occurs until the 14th when the position of the center is assumed from later observations to have been about 14° N. latitude and 37½° W. longitude. The cyclone, from this point, is represented as travelling W.N.W. on a curve trending more northwardly as it nears the West India islands, and still more to the northward after passing St. Thomas, to a point about two hundred miles west of Bermuda; after which it takes a north-easterly course until it strikes the south shores of Newfoundland where it is supposed to have spent itself on the 27th, as no trace of it was found after that date. By projecting a circle with a radius of three hundred miles from the center, as marked each day on the charts, I find that the number of observations obtained within the storm area proper, varies from one to thirty daily, after the 18th when the storm was fully developed, to the 27th when it broke up, in all about eighty-six observations.

From these data Captain Toynbee concludes that the wind, instead of blowing in circles, has a mean indraft of about 29° or in other words that the angle between the direction of the wind and the bearing of the center is about ten and a half points instead of eight points as taught by the cyclone theory. A table on page eighty-nine showing the mean of one hundred observations, gives a mean angle of 119°.

On page 88 is a diagram, (Plate II, Fig. 5), showing the probable course of the wind in the stormdisk, plotted from observations on the 25th of August when the position of the center was pretty well known.

On August 23d at 11h. 20m. A.M., an American mail steamer (*Albermarle*) hove to north of the center (distant about two hundred and twenty-five miles by chart) to ascertain the course of the storm, and having laid to for two hours without a change of wind and with a falling barometer (from 29.94 in. to 29.80 in.) the master concluded that he was on the track of an advancing storm, and at 1h. 20m. P.M., started to run N.W. by W. wind E. by S. a little on starboard quarter. At 4h. 40m. P.M., barometer again registered (29.94 in.) wind and sea had moderated and the squalls were less frequent.

From 4h. 40m. P.M. (23d) to 4h. 40m. A.M., (24th) barometer remained steady, during which time as the wind backed to the northward the ship steered W.N.W., West, W.S.W., S.W. and South which course she was steering at 4h. 40m. A. M., at which time the weather was more moderate, without squalls and clearing. After this time she resumed her course S.S.E. ½ E. the barometer rising gradually.

By a glance at the diagram (Fig. 5) it would appear that such a manœuvre was not possible, and therefore it may reasonably be supposed that this diagram does not correctly represent the circulation of air in the storm during the 23d and 24th when the *Albermarle* did perform it.

Again we have a diagram by Dr. Meldrum (Plate II. Fig. 6) which like the above I have roughly copied from page 88 and which is supposed to represent the circulation of air in the Mauritius hurricane of February 25th, 1860, the same as heretofore alluded to at Réunion island. By a glance at the diagram it appears that a vessel running before the wind must inevitably bring up in the center ; and yet Captain Bridet in his account of this same cyclone has clearly shown, that four (4) vessels did cross its track running before the wind, one of them within thirty-five miles of the center and all escaped without serious injury. It is not necessary, neither have I time or space in this paper to criticise this work as under other circumstances I might. I will simply say, that, as a purely meteorological work it is doubtless very valuable, but as an exposé of the cyclone problem it cannot be classed very high, for the simple reason that the system of simultaneous observations confined to one particular moment of each day as is the case in this instance, is not calculated to give very satisfactory results in this respect, and beyond the fact of showing that a storm actually did pass over or near the track projected on the diagram accompanying the daily charts, it has proved nothing new. The mere fact of a gust of wind rushing wildly toward the center for ten or fifteen minutes, about the time for which the chart is plotted, does not by any means disprove the circular theory. Every seaman who has ever had the responsibility of a ship in a gale at sea, knows very well, how anxiously he has stood on the quarterdeck watching his close-reefed main-topsail and wondering whether it would stand such another flap as the last one, or whether the next would split it into a thousand pieces.

It must be remembered in this connection that the author and advocates of the cyclone theory do not claim that the winds blow absolutely in circles, such as would be formed by steel springs bent into that form ; it is well known that certain irregularities in the course of the winds due to local disturbances frequently take place within the storm-disk, and Mr. Redfield in the " American Journal of Science and the Arts," second series No. 1, page 14, says :* " When in 1830, I first at-

* See also Piddington's Hornbook, page 108.

tempted to establish by direct evidence the rotative character of gales or tempests, I had only to encounter the then prevailing idea of a general rectilinear movement in these winds. Hence I have deemed it sufficient to describe the rotation in general terms, not doubting that on different sides of a rotatory storm as in common rains or sluggish storms, might be found any course of wind, from the rotative to the rectilinear, together with varying conditions as regards clouds and rain.

The common idea of rotation in circles, however, is sufficiently correct for practical purposes and for the construction of diagrams. * * * * * The degree of vorticular inclination in violent storms must be subject, locally, to great variations; but it is not probable that, on an average of the different sides, it ever comes near to forty-five degrees from the tangent of a circle, and that such average inclination ever exceeds two points of the compass may well be doubted."

The incurving of the wind and a few isolated irregularities in its course, is all that appears to me to be proved by this investigation of the August storm, and this knowledge, as I have shown, is not new.

There is evidently need of more information on this subject, but it is not attainable by the system of simultaneous observations as now practised; this I admit will greatly assist the investigation, but if we wish to know what is going on in a storm five hundred miles east of cape Henry, or anywhere else beyond the limits of the signal-service-men on shore, we must send seamen there in ships to find out, and to this end we must educate and interest our merchant-seamen in the work, by instructing them how to observe and how to record their observations.

This work has been inaugurated and is now fairly started by the U. S. Hydrographic office at Washington, D. C., where Journals are prepared in a desirable and convenient form and issued free of charge to any and all seamen who will promise to keep them faithfully and return them to the office when filled. These Journals contain, besides the forms for recording observations, full and complete instructions as to the manner in which they should be kept and are embellished with elaborate illustrations and explanations of the instruments employed in making the observations.

By this method only can we hope to settle the much disputed question of: How the winds blow within the stormdisk.

I trust the day is not far distant when this important undertaking shall be crowned with all the success it deserves, and when every sea-

man, naval as well as merchant, shall feel that he has a special and personal responsibility to meet in connection with this work, and when in consequence, he shall prosecute his researches to the full extent of his opportunity for doing so.

A few years of lively investigation of this kind will make up for lost opportunities in the past and most of us here may reasonably hope to see the final solution of the storm problem, at least that part of it which affects the management of a ship and the manner of avoiding danger.

There are certain other things which might properly come within the scope of this paper, such as cyclones following each other, traveling near each other on parallel tracks or crossing; but all such cases are so fully discussed in all the standard works on storms that it is not necessary here to say anything about them.

The action of the barometer and the indications of a storm as well as the rules for avoiding it are matters of general interest and doubtless familiar to all of us, I will therefore touch but briefly on these points before concluding.

## REMARKS ON BAROMETER AND STORM INDICATIONS.

Barometer. The barometer as an instrument of warning, and also an approximate measure of the distance from the center of a cyclone is of vital importance to the seaman.

First. The barometer generally indicates the approach of a storm by a restless oscillating motion of the mercury, caused by a disturbed condition of the atmosphere in the vicinity of a storm and the consequent passage over it of atmospheric waves of different heights. These oscillations have been observed to vary from a just perceptible motion to 0.02 inches.

Second. The barometer often rises suddenly just on the border in front of a storm, by reason of the air banking up there, and therefore, if the clouds and general appearance of the weather indicate the approach of a storm the rise in the barometer, if any occurs, is no guarantee that it will not come, but rather a sign that a severe storm is coming. (The barometer will probably not rise much in front of a slowly moving storm.) Had the captain of the *Francis Henty* properly interpreted his barometer, he would have remained westward of the islands and kept out of trouble.

Third. A very rapid fall of the barometer after fairly entering the

stormdisk, may be regarded as evidence of a very violent storm of small diameter, and a gradual fall would indicate the contrary.

Fourth. If a vessel by any accident was caught in a cyclone, situated as the vessel which in a preceding paragraph I have pictured on the east coast of Formosa, the knowledge of her distance from the center would be all important, even if it could not be determined nearer than fifty miles, and to aid navigators in determining probably within that distance, the distance from the center, a table is published in Piddington's Horn book, 3d edition, page 252, which I give here for what it is worth, and which in an extreme case may prove of service.

| Average fall of Bar pr. hour | | | | Distance in miles from Center. | | | |
|---|---|---|---|---|---|---|---|
| From | 0 .02 in. | To | 0 .06 in. " | From | 250 | To | 150 |
| " | 0 .06 in. | " | 0 .08 in. " | " | 150 | " | 100 |
| " | 0 .08 in. | " | 0 .12 in. " | " | 100 | " | 80 |
| " | 0 .12 in. | " | 0 .15 in. " | " | 80 | " | 50 |

I have compared the fall of the barometer in a great number of cases with the above and generally found the result very favorable.

The indications of the approach of a cyclone do not differ materially from those of the ordinary gale ; but a few such, as a hard steel gray sky or having a greenish tint, a blood red or bright yellow sunset, a heavy swell unaccounted for in any other way, and a thick lurid appearance of the sky, may be regarded in connection with a general threatening appearance of the weather, and particularly with a restless state of the barometer, as significant signs of a more than ordinary gale, and, whether seen separately or together, ought not to be disregarded.

When by any of these signs or by the action of his barometer the navigator has reason to suspect that a cyclone is not far distant, his first care is to devise a plan for avoiding it, and if he knew positively the direction of its course this might sometimes be accomplished. An approximate idea of the storm's movement in certain localities may be had by an inspection of a cyclone chart such as is found in the standard works on storms—but although the cyclone tracks generally lie in the same direction and as a rule not very far apart, probably not more than four or five hundred miles at any given point, yet it does not follow as matter of course that every cyclone travels over the beaten track, and therefore, there is no certainty that the approaching storm will do so. By a knowledge of the tracks in the locality the navigator may, however, try to avoid it, but if after doing his very best to effect this he is still caught in the storm, he must then as quickly as possible determine his position in the stormdisk and the course

of the storm. This may always be done by a knowledge of the following few, simple facts committed to memory, viz.:

## RULES FOR AVOIDING THE CENTER.

Right Semicircle—Wind changes to the right N. E. S. W., heave to on *starboard tack.*

Left Semicircle—Wind changes to the left N. W. S. E., heave to on *port tack.*

This is all that is necessary to place the ship in a safe position north or south of the equator until the course of the storm is determined. This may further be reduced to six words, by associating the direction of the change of wind, with the semicircle of the storm and the tack to heave to on—and taking them in this order we would have for the right semicircle: *Right-Right-Starboard,* and for the left semicircle: *Left-Left-Port.*

In order to simplify the problem as much as possible, I have discarded the terms: *Dangerous* semicircle and *manageable* semicircle and substituted right and left semicircles. The right semicircle being that portion of the stormdisk situated on the right of the axis of the storm track, looking in the direction of its course, and the left semicircle the portion of the stormdisk lying on the left of that line.

### ROTATION OF WIND.

Northern hemisphere—from *Right to left* N. W. S. E., left handed, or, in nautical language, against the sun.

Southern hemisphere—from *Left to Right.* N. E. S. W., right handed, or, as a sailor would say with the sun.

### BEARING OF CENTER.

Northern hemisphere—8 points (90°) to the *right* of the wind point, looking in the wind's eye.

Southern hemisphere—8 points (90°) to the *left* of the wind point, looking in the wind's eye.

Two bearings of the center with an interval of from 2 to 3 hours between will in general be sufficient to determine the course of the storm, provided an accurate account has been kept of the ship's way; but if the storm is moving slowly a longer interval may be necessary. There are but two points in the stormdisk of a cyclone where a vessel hove to will not experience a change of wind—one is in front of the center on the line of its axis and the other in rear of the center on the same line; for these two cases the barometer must be the guide—in front of the center it falls and in rear of the center it rises.

There are also five points in the storm disk of a cyclone, where a vessel may run along with the storm, parallel to its course, and at equal speed; without having any change of wind, and with a steady barometer.

NORTHERN HEMISPHERE.

1st. *In front of the center on the line of its axis.* Wind on starboard beam.

2nd. *Anywhere in the right forward quadrant.* Wind on starboard side abaft the beam.

3rd. *In rear of center on the line of its axis.* Wind on port beam.

4th. *Any where in the right rear quadrant.* Wind on port side abaft the beam.

5th. *Abreast and to the right of the center.* Wind aft.

SOUTHERN HEMISPHERE.

1st. *In front of center on the line of its axis.* Wind on port beam.

2nd. *Anywhere in the left forward quadrant.* Wind on port side abaft the beam.

3rd. *In rear of center, on the line of its axis.* Wind on starboard beam.

4th. *Anywhere in the left rear quadrant.* Wind on starboard side abaft the beam.

5th. *Abreast and to the left of center.* Wind aft.

The above manœuvres are possible providing sail can be carried, but only three of them are advisable, viz: the position abreast of the center, in the rear quadrant, and in rear of the center. Running along with the storm in front of the center or in the forward quadrants should never be resorted to, as an accident to sails or spars, temporarily disabling the vessel, would at once place her in great danger of being overtaken by the center.

TO RUN OUT OF THE STORM IN THE NORTHERN HEMISPHERE.*

RIGHT SEMICIRCLE. Haul by the wind *on starboard tack* and carry sail as long as possible; if obliged to heave to, do so on *starboard tack.*

LEFT SEMICIRCLE. Bring the wind on *starboard quarter.* Note the direction of the ship's head and steer that course. If obliged to heave to, do so on *port tack.*

ON THE STORM TRACK in front of center. Square away and *run before it.* Note the course and keep it, and trim the yards when the

* See Storm card, Northern Hemisphere. Plate III.

wind draws on the starboard quarter. If, however, obliged to heave to, do so on *port tack.*

ON THE STORM TRACK in rear of center. *Run out* with wind on *starboard quarter*, or heave to on *starboard tack.*

TO RUN OUT OF THE STORM—SOUTHERN HEMISPHERE.*

RIGHT SEMICIRCLE. Bring wind on *port quarter.* Note the course and keep it. If obliged to heave to, do so on *starboard tack.*

LEFT SEMICIRCLE. Haul by the wind on *port tack.* Carry sail as long as possible, and if obliged to heave to, do so on *port tack.*

ON THE STORM TRACK in front of center. *Run before it.* Note the course and keep it, and trim the yards as the wind gradually hauls on the port quarter. If obliged to heave to, do so on the *starboard tack.*

ON THE STORM TRACK in rear of center. *Run out* with the wind on port quarter or heave to on *port tack.*

A rise in the barometer, improvement of the weather, and a gradual abatement of the force of the wind, will result from the above manœuvres; and the ship should in each case be kept on her course until by these signs it is made evident that she is out of danger.

All the above manœuvres depend of course on sea room, and the ability to carry sail. If sail cannot be carried or land interferes, the ship must be hove to on the *starboard* tack in the *Right* semicircle, and on the *port* tack in *Left* semicircle, and never otherwise. The old popular idea of heaving to on the starboard tack in the northern hemisphere and on the port tack in the southern hemisphere, under all circumstances, has been revived by a late writer,† and is advocated even by some seamen. I strongly protest against this practice as being likely to lead to the destruction of life and property.

It is asserted as a reason for doing so, that a vessel so disposed lies with her head from the center, which is true; but she also lies with her quarter to the sea, even if she is not taken aback and swamped before the wind has headed her off that far. A vessel will not head reach laying-to under storm canvas, probably nothing but a storm mizzen, and the suggestion is so unseamanlike, that I am inclined to believe that those who write on the subject and recommend such a thing are not familiar with the management of a ship in a gale; and, that the seamen who hold such opinions, have not given the case the consideration it deserves; in other words, that they have forgotten all about the sea, in the dread contemplation of the center.

* See Storm Card. Southern Hemisphere. Plate III.

† Mr. Kellar.

It must be remembered that the wind changes much more rapidly than the sea ; and I have laid to in the right semicircle of a cyclone in the southern Indian ocean on the starboard tack, when in the heaviest sea near the end of the storm, the ship was lying nearly head on to the seas. It is not necessary to state here what would have been her position with respect to the sea or the inevitable consequence, had she been on the port tack.

It sometimes occurs, although the cases are very rare, that a cyclone takes a sudden turn, and recurves on its track so much as to render a vessel liable to run into it a second time.

Colonel Reid, in his work on the Law of Storms, (page 173 and following,) recites a remarkable instance of this kind, which occurred in the year 1809, in the Indian ocean, southward of the island of Mauritius. A cyclone was encountered by H. M. S. *Culloden*, convoying a fleet of the Hon. East India Company's ships, bound homeward, near the twentieth parallel of latitude; at which time the storm was travelling about W.S.W., and after passing over the fleet continued its course until near the twenty-fifth parallel, when it suddenly turned towards the E.S.E., and the fleet steering about S.W., ran into the storm a second time, and several of the ships were lost.

But at that time nothing was known of the *Law of Storms*, and the popular thing appears to have been to scud before a gale, which some of these vessels did, and were lost in consequence, being in the left semicircle where they ought to have laid to on the port tack, instead of attempting to cross the storm track by scudding.

A similar case occurring at the present day, would be very much simplified, as we can readily locate the center and determine the direction of its movement.

In conclusion I would say : Although my argument has been made in support of, and as far as may be to prove what many will doubtless say has been an established fact for fifty years, (with which opinion I am myself in perfect accord), yet in view of the fact, that efforts have in late years been made to overthrow a system, which, during the same length of time (nearly) has been the only safeguard to navigation as far as concerns ocean storms ; and further, that as these efforts have not only failed to stand the test when compared with facts, but have suggested no new or better method by which to insure the safety of a ship at sea, I have thought myself justified in thus occupying your time and trying your patience, and I trust I may not have been mistaken.

The PRESIDENT. I will simply say that I, myself, have had opportunities of verifying the circular theory of hurricanes which is so generally received, I mean the theory of Redfield; and I have, by following the rules laid down by him, avoided storm centers.

When I was first in the East Indies, I gave a great deal of attention to storms. The opinion at which I arrived after much experience and reading on the subject, was in entire conformity with Redfield's theory. The incidents of the hurricane themselves were not different from those recorded in books. I acted upon the assumption that Redfield's theories were right and in practice I found them true. I believe that Espy's theory is wrong, and will not stand investigation.

Rear-Admiral J. J. ALMY. If there are no further remarks on this subject, I move that the thanks of this meeting be tendered Lieut.Commander NELSON for the very instructive paper he has read to us this evening.

The motion was carried unanimously.

# THE RECORD

OF THE

# UNITED STATES NAVAL INSTITUTE.

NAVY DEPARTMENT, WASHINGTON,

APRIL 10, 1879.

Chief Engineer I. R. Mc NARY, U. S. N., in the Chair.

## THE BOILER POWER OF NAVAL VESSELS.

By PASSED ASSISTANT ENG. C. R. ROELKER, U. S. N.

The problem to be solved in designing the machinery of a vessel may be stated in general terms as follows: a given amount of power is to be developed for a given length of time at a minimum of cost. It must be borne in mind, however, that the cost of the developed power does not comprise only the interest on the capital representing the original cost of the machinery, the money value of the fuel consumed, the wear and tear, and other running expenses,—but includes the value of the *weight* of the machinery and the fuel, and of the *space* occupied by them, in so far as they reduce the carrying capacity of the vessel. For a steamer designed to trade between certain ports it is easy to determine what ratio the expenses should bear to the carrying capacity, to make the vessel a remunerative investment. The total cost of driving a vessel with a certain power may be calculated in dollars and cents, and compared with the value of her carrying capacity and speed; and the proportions promising the greatest relative economy may thus be determined.

This exact method cannot be applied to naval vessels; the value of the different qualities which a man-of war must possess, cannot be measured by a commercial standard, nor are these qualities of the same relative importance under all circumstances.

In the following investigation we will not consider vessels designed for special purposes, as torpedo-boats, rams, floating batteries, &c., but have only regard to cruising vessels intended for general service, in which either the armament, or the speed, or the ability to keep the sea a long time becomes, according to circumstances, the most important

factor of efficiency. Experience has determined what fraction of the whole weight of the vessel, and how much space is to be allotted to the motive power, to the armament and to the equipment respectively, to render the general efficiency of the cruiser a maximum. The problem to be solved in designing the steam machinery consists in making such use of the space and weight allotted to the machinery and the fuel, as to produce the greatest possible effect; and the efficiency of the machinery is to be measured by a two-fold standard, viz., 1st, by the total distance through which the vessel can steam at various rates of speed, and 2nd, by the highest rate of speed which can be maintained for a certain length of time. The cost of the fuel, an important element in the efficiency of a mercantile vessel, is of relatively small importance in the case of a man-of-war.

There are a number of important conditions not to be lost sight of in the design of the machinery of a cruising man-of-war,—demanded by the varying nature of her service, and imposing many restrictions on the designer. It must be borne in mind that the greatest power which the machinery is capable of developing will be called into use only on exceptional occasions; that, therefore, the vessel must steam most economically with a fraction of the total power;—that to be prepared for all emergencies, the boilers must be able to generate steam rapidly; that the machinery must preserve its efficiency under all the varying conditions of long cruises at any part of the world, with few facilities for repairs, and often for many months without an opportunity for those periodical examinations, cleanings and adjustments, which are so essential for the preservation of the efficiency of all machinery. Besides it is not sufficient to give such structural strength to certain parts of the machinery, especially to the boilers, as is demanded by the stresses produced when working with the greatest power, but the effect of violent concussions by ramming or the explosion of torpedoes, and the chances of penetration by shot, must be taken into consideration. To protect the machinery against this latter contingency in an unarmored vessel, it has to be placed as low as possible, the waterline being generally assumed to be the extreme limit which any vital part of the machinery is allowed to reach. This restriction in regard to height not only necessitates an increase in the space occupied by the machinery in the length and breadth of the vessel, but it often precludes the adoption of arrangements which would insure greater economical efficiency.

These considerations are sufficient to indicate that the economy and

efficiency of the steam power of mercantile and naval vessels can not be measured by the same standard, and that there are also essential differences in the choice of the general arrangements and of the details of construction of the boilers of these two classes of vessels.

In modern cruising vessels of the English and French navies, of more than fifteen hundred tons displacement, the total weight of machinery, fully equipped for service, is from twenty to twenty-five per cent. of the displacement, and the weight of fuel carried in the bunkers varies between ten and fifteen per cent. of the displacement; and with these proportions, the highest number of indicated horse powers developed by the machinery is from ten to twenty-five per cent. greater than the number of tons representing the displacement of the vessel. In recently constructed vessels of the French navy the proportion of weight of machinery to displacement is, on the whole, somewhat greater than in English vessels, at the expense of their armament and equipment; but in the two fast English despatch vessels, the *Iris* and the *Mercury*, the weight of machinery forms nearly twenty-seven per cent., and that of the fuel twenty per cent. of the total displacement, and the highest number of indicated horse-powers developed by the machinery of the *Iris* was more than twice as great as the number of tons representing the displacement of the vessel.

The weight and space required for a given type of the engines proper may be considered as being very nearly a fixed quantity for a given number of indicated horse-powers. But the weight and space required for boilers capable of furnishing a given power may vary considerably, depending, *first*, on the form of their shell, the arrangement of their internal parts, and their location in the vessel with regard to each other; *secondly*, on the rate of combustion and the economic evaporative efficiency of the boilers.

The return tubular boiler, with the tubes arranged directly over the furnaces, combines so many advantages respecting economy in weight and space, and general maintenance. in comparison with its evaporative efficiency, that it is almost universally used on board of sea-going vessels, and in fact it is called the marine boiler *par excellence*. When this arrangement of tubes is departed from, it invariably entails a loss of space in the vessel, and it is done, therefore, only under exceptional conditions: for instance, in vessels of very light draught it may be necessary to reduce the height of the boiler by placing the tubes on a level with the furnaces instead of above them, in order to get the boiler below the water-line of the vessel. The vertical tubular boiler of

the Martin type, which formed for many years a distinctive feature of our naval steamers, has of late almost disappeared, having given way to the horizontal tubular boiler. We cannot enter farther into the question of the relative merits of these two types of boilers, than to state that, while the vertical water-tube boiler has the advantage of greater economical evaporation, the horizontal tubular boiler is capable of developing more power because it is capable of maintaining a higher rate of combustion, with natural draught.

As far as the form of the shell is concerned, two types of boilers have to be considered, viz., the rectangular boiler and the cylindrical boiler, each possessing peculiar merits. The question, which of these two types is better adapted for naval purposes, is an intricate one, and can be solved only after a thorough, long-continued, practical test. At present we can give only a brief statement of their respective characteristic features, and point out how they bear on the question of efficiency and economy in the performance of naval vessels. Modifications or combinations of these two forms, like the semi-cylindrical, the oval, and the cylindrical lobe boiler, may be used under special conditions; but, in general, they possess the defects of both types without their most characteristic advantages; they need not be considered here any farther. The oval boiler is, however, used very extensively at present in the English Navy.

The rectangular boiler, which depends for its strength almost entirely on the bracing, is nearly universally used in naval vessels as long as the steam pressure does not exceed forty or forty-five pounds per square inch above the atmosphere. The principal advantage connected with the rectangular shell, lies in the fact that it utilizes the whole of the space occupied by it in the vessel, and is easily adapted to any arrangement of the interior parts. Seven furnaces, having an aggregate grate-surface of about one hundred and forty square feet, and the required heating surface, viz., from twenty-five to thirty times the area of the grate-surface, may be arranged within a single shell about twenty-five feet long, from nine to ten feet wide, and from nine to ten feet high. This whole space is utilized to the best advantage for the purposes of generating and storing the steam, and little more water is carried than is necessary to ensure proper circulation. It is readily seen, that the greater the area of grate-surface contained in a single shell, the less will be the weight of the boiler relatively to its power; it is, however, impracticable to make marine boilers much longer than twenty-five feet.

When the steam pressure exceeds forty-five pounds per square inch, the use of cylindrical boilers becomes advisable. The cylindrical shell possesses a special fitness for resisting an internal pressure, which produces on every portion of it a uniform tensile stress ; in this manner it is exempt from the evils resulting from the varying bending stresses to which, in the rectangular boiler, each portion of the shell lying between adjacent braces is subjected, and which must ultimately cause leaks around the rivets, open the seams and separate the fibres of the metal. The bottom of the cylindrical boilers, inside and outside, can be made much more accessible for examinations and repairs, than is the case with the rectangular boiler. For these two reasons we may assume that, under like conditions of working, the cylindrical shell is more durable than the rectangular shell. It is stated by Lloyd's surveyors as a matter of experience, that in cylindrical boilers the flat ends, which are stayed in the same manner and experience the same strains as rectangular shells, deteriorate much quicker than the cylindrical shell. In the event of perforation by shot, the chances of destruction would probably be equal for both types of boilers ; but it may be assumed that the cylindrical boiler will bear violent concussions more safely than the rectangular boiler. The diameter of the cylindrical shell is limited, of course, by the height which the boiler is allowed to attain ; and thus, in vessels of relatively light draught, the number of cylindrical boilers has to be increased as their diameter decreases. This subdivision of the boiler power has its advantages, as well as very serious disadvantages. One or more of these boilers may be disabled without crippling fatally the motive power of the vessel. When it is desirable to use only a fraction of the boiler power, it is more economical to disconnect completely several of these boilers, than merely to reduce the grate-surface in the large rectangular boilers. The violence of boiler explosions depends on a variety of circumstances ; but it appears that the damage done by them bears some ratio to the quantity of water carried in the boiler, and this quantity is necessarily much less in each of the smaller cylindrical, than in the large rectangular boilers. On the other hand, the great number of separate attachments required by the numerous cylindrical boilers, increase greatly their cost, weight and liability to derangement. But the most serious objection to cylindrical boilers, is the fact that this form does not utilize the space occupied completely. A cylindrical boiler twelve feet in diameter may contain three furnaces, each three feet in diameter. Two of these boilers placed side by side, occupying almost exactly the same space in

the length and breadth of the vessel as the above mentioned rectangular boiler, but being about two feet higher, contain fourteen per cent. less grate-surface; and this loss in area of grate, relatively to the area occupied by the boilers on the floor of the vessel, increases rapidly as the diameter of the boilers decreases.

The question whether cylindrical or rectangular boilers should be used in naval cruising vessels, must be determined according to the rule regarding the measure of efficiency, laid down in the beginning of this essay. The saving in fuel, due to the use of steam of a high pressure, must be sufficient to counter-balance the loss in weight and space due to the substitution of the high-pressure cylindrical, for the low pressure rectangular boiler; or to state this point more precisely, with the same aggregate weight and space allowed for boilers and coal, that type of boiler which enables the vessel to steam a greater distance at the same rate of speed, is the preferable one. This question cannot be decided by deductions drawn from theoretical rules, or from the results of special trials of short duration; but a careful comparison of data furnished by repeated trials under all the varying conditions of a cruise can alone give a final answer.

It may be proper to remark here, that the space required for the boilers includes also the fire room. The natural arrangement of the boilers in pairs opposite to each other, with the fire room running between them in a fore and aft direction, will not be departed from, except when, as in some English vessels of recent construction, the hold of the vessel is sub-divided by longitudinal bulkheads into water-tight compartments, and a different arrangement of the boilers becomes a necessity, notwithstanding the loss in space, and the many other inconveniences produced thereby.

With the ordinary types and arrangement of boilers, the space required for them is in the direct ratio of their grate-surface; but this ratio is greater for cylindrical than for rectangular boilers, and increases as the diameter of the cylindrical boilers decreases.

The efficiency of the machinery of a vessel is frequently measured by the number of horse-powers developed per square foot of grate surface. Leaving out of account the efficiency of the engines proper, the power of the boilers is measured by the weight of steam generated in a unit of time, and depends on the proportions of calorimeter and heating surface to grate surface, and on the rate of combustion, or the weight of a given kind of fuel consumed per square foot of grate-surface per hour. The calorimeter and heating surface determine the

quantity of heat per unit of weight of fuel available for the purpose of generating steam; by augmenting the heating surface, the weight and bulk of boilers are necessarily increased, and a limit is soon reached where the economical advantage resulting from such an increase vanishes The rate of combustion determines the total heat available for the evaporation of water in a unit of time; but with given proportions of the boiler, the weight of steam generated per pound of fuel diminishes with an increased rate of combustion. Consequently, when a given weight of steam is to be generated, or in other words, a given amount of power is to be developed for a given length of time, this result may be obtained in two different ways; viz., either large boilers with a low rate of combustion, but high economic evaporative efficiency, or smaller boilers with a higher rate of combustion but lower economic evaporative efficiency, may be used; in the first case, the weight and space required for the boilers will be greater, while the weight and space required for the fuel will be less than in the second case. It is necessary to determine that rate of combustion and those proportions of the boilers, for which the aggregate weight and space required for boilers and fuel, in order to develop a certain power for a given length of time, become a minimum. It is evident that, the longer the time during which the power is to be developed, the greater will be the loss of fuel due to a diminished economic evaporation with an increased rate of combustion: consequently, the rate of combustion, which gives the most economical results in respect of weight and space required, is a decreasing function of the time during which the power is to be developed. This question is discussed in a very instructive manner by Chief Engineer Isherwood, U. S. N., in the second volume of his "Engineering Researches." Basing his conclusions on data derived from the numerous boiler experiments made under his direction, he finds that, measured by economy in the aggregate weight and space required for boilers and fuel, the most advantageous rate of combustion for steaming during 200 consecutive hours, is about twelve pounds of anthracite coal per square foot of grate per hour, when the heating surface of the boiler is twenty-five times the area of the grate surface, and the calorimeter is one-eighth the area of the grate. The tables given in the above mentioned work furnish the ready means to calculate the effects which a change in the rate of combustion, or in the length of the steaming time, has on the economy in space and weight, and thus to determine the most efficient proportions of the boilers, in so far as their efficiency is measured by the length of time during which

they are capable of furnishing a given power with a fixed amount of aggregate weight and space required for boilers and fuel.

We have assumed that a second measure of the efficiency of a vessel-of-war is the highest speed which she can maintain for a certain length of time. It may be all-important at times to push the development of power, that is to say the speed of the vessel, up to the highest possible limit, irrespective of economical considerations. To this end the rate of combustion must be increased far beyond the economical limit; and it is an important question, how much the power of a given boiler can be increased by increasing the rate of combustion.

Isherwood states that "when the boilers are placed in the hold of a vessel, and the air has to reach their ash-pits through the restricted hatches of the decks, an air-current from the upper deck to the ash-pits having to be produced at the expense of the draught of the boilers," and "the calorimeter being one-eighth of the grate surface, the heating-surface twenty-five times the grate surface and the chimney sixty feet high above the grates"—"it is found experimentally, that the maximum rate of combustion by natural draught is, for the horizontal fire-tube boilers, sixteen pounds of anthracite per square foot of grate-surface per hour." This rate of combustion is 33 per cent. greater, and furnishes 15 per cent. more steam than the rate which was found to be most economical in respect of weight and space required for two hundred hours steaming. Any further increase is impossible with anthracite coal, unless the draught be aided by artificial means.

When, on the other hand, a free burning bituminous or semi-bituminous coal is used as fuel, from sixteen to twenty pounds can be burned economically in marine boilers per square foot of grate per hour with natural draught; and by urging the fires, this quantity may be increased to twenty-seven pounds with certain kinds of coal. For an increased rate of combustion it becomes necessary to increase the proportions of heating-surface and calorimeter to grate-surface, in order to preserve the economic evaporative efficiency of the boiler, and this causes a slight increase in the total weight of the boiler relatively to the area of its grate. The space required to stow the bituminous coal is from five to fifteen per cent greater than that required for an equal weight of anthracite; this greater bulk of the bituminous coal is, however, fully offset by the greater amount of refuse in ashes and clinker produced in the combustion of our anthracite coals. Our Pennsylvania anthracites give on an average from twelve to twenty per cent. of refuse, while the better classes of English semi-bituminous coal

produce only from six to twelve per cent. of ashes. The saving in weight and bulk of boilers due to the increased rate of combustion is so great, that all the lines of transatlantic steamers use semi-bituminous coal exclusively, although its cost in our market is fully fifty per cent. greater than that of anthracite. The average rates of combustion of a large number of steamers of different lines running between New York and England, range between thirteen and nineteen pounds per square foot of grate per hour.

The use of semi-bituminous coals has the additional important advantage for ships of war that steam can be raised with them in a much shorter time than with our hard anthracites; they are, therefore, used on the naval vessels of all foreign nations, England furnishing the chief supply to most of the European countries. Great care is exercised in selecting these coals according to the service to be performed by the vessels. French naval vessels, during trials and for special service, burn Newcastle and Cardiff coals, mixed in equal proportions; for ordinary service, French coals, mixed in various proportions according to their more or less bituminous character, are used.

No coal is accepted unless it produces less than two per cent. of clinker, and less than thirteen per cent. of soot and ashes. In the English Navy, all cruising vessels burn now a mixture of equal weights of the smokeless, friable Welsh coal and of bituminous North Country coal; for trials and special occasions a carefully picked Welsh coal, containing not more than six per cent. of refuse, is furnished. The English have made repeated trials of burning the hard Welsh anthracites in their naval vessels, but the result was such a large reduction in the rate of combustion, and, consequently, such a falling off in the highest speed of their vessels that the attempt had to be abandoned. In fact, English and French writers generally consider the use of hard anthracite coals as fuel for marine boilers as impracticable.

The selection of anthracite as fuel for our naval vessels was the result of the extensive experiments and investigations made, by authority of Congress, in the years 1842-43 by Professor Walter Johnson of the Smithsonian Institution. Pure anthracite will evaporate more water per pound of fuel in a steam boiler than coals containing various proportions of bituminous substances: its freedom from smoke and relatively small liability to deterioration from exposure are great advantages in favor of its use on board of cruising vessels. But it is evident that means must be provided to increase the ordinarily slow rate

of combustion with this coal, if our boilers are to produce the same power per square foot of grate-surface as foreign naval vessels. In the first place the chimney of our boilers should be made as high as practicable; and neither the arrangement of the rigging, nor mere æsthetical considerations should be allowed to limit its height. Special attention should also be paid to giving to the air the freest possible access to the fire-room. In the second place special machinery must be provided to increase the draught of the boilers artificially.

The U. S. S. *Mackinaw* and *Eutaw* had vertical water-tube boilers of the Martin type; the proportions of heating-surface and calorimeter to grate-surface being respectively as 25.18 to 1, and as 1 to 7.5. With natural draught the highest rate of combustion was 11.67 pounds of Pennsylvania anthracite coal, producing 16.6 per cent. of refuse. Forcing air into the ash pits by means of a fan-blower raised the rate of combustion to twenty seven lbs. of the same kind of coal; and by increasing, in this manner, the rate of combustion 131 per cent. the total horse power of the boilers was increased from 75 to 85 per cent. This method of blowing air directly into closed ash pits is connected with such serious inconveniences that it can be used only under exceptional circumstances. When the fire room is enclosed by tight bulkheads, it is a good plan to produce an increase of pressure in the fire-room by forcing air into it. With an open fire room an exhaust fan connected with the chimney would promise good results, but the practical difficulties connected with its application are great. The simplest means of increasing the draught is the steam jet, which may be applied to any boiler, and no naval vessel should be without it. It is true, it is wasteful, but it has the great advantages of occupying no useful room, of being of inexpensive construction, and of not being liable to derangement. Isherwood found that the rate of combustion of anthracite coal in naval boilers might be increased 73.89 per cent. with an expediture of 9.73 per cent. of the steam by the jet; and that the jet used 8.21 per cent. more steam of the total amount evaporated than the fan, for equal rates of combustion.

The foregoing inquiry will show how important it is, in designing the machinery of naval vessels, to distinguish between the means of attaining the most efficient cruising speed, and the highest possible speed of the vessel; the former must determine the dimensions and proportions to be given to the machinery, so as to secure the greatest efficiency with the allotted weight and space; the latter determines the limit of the capacity and strength of certain parts. Dislère states that for

the pursuit of the ordinary merchant fleet in time of war a speed of ten knots would be sufficient for a cruiser; and Barnaby, Chief Constructor of the British Navy, assumes that cruising vessels of about nineteen hundred tons displacement should attain a speed of not less than thirteen knots on the measured mile. Accepting the opinions of both these authorities as correct, we must give such proportions to the boilers of our ordinary cruising vessels as will enable them to steam for the greatest length of time at a speed of ten knots an hour, with a given space allotted to, and weight of, machinery and fuel; and since for a speed of thirteen knots more than double the power required for ten knots has to be developed, we must provide means which make it possible to increase the rate of combustion correspondingly. For instance, in case the vessel is to be able to steam with the amount of fuel in her bunkers, at the rate of ten knots an hour for ten or twelve consecutive days, the grate surface would have to be proportioned so as to furnish the required power with a rate of combustion of from seven to eight pounds of anthracite coal; and in order to drive the same vessel at a speed of thirteen knots, the rate of combustion would have to be increased to about twenty four pounds of anthracite coal for the same grate-surface.

Vessels designed for the special purpose of intercepting mail steamers and fighting the fast cruisers of the enemy require not only a higher possible speed, but their machinery should be proportioned so as to attain the greatest efficiency at a relatively higher rate of speed than is done in the former class of vessels.

It may be instructive to illustrate some of the principles laid down in this essay by an example taken from our own naval service. The U. S. S. *Quinnebaug*, and class, have a load-draught displacement of nineteen hundred and ten tons. Their engines were originally duplicates of those of the four vessels of the *Alaska* class, but were converted from simple engines into compound engines, using steam of eighty pounds pressure above the atmosphere. The steam is furnished by ten cylindrical boilers having a diameter of eight feet, and a length of eight feet one inch. Each boiler contains a single cylindrical furnace-tube, and the horizontal return-tubes are arranged over and at the sides of the furnace. The aggregate area of grate-surface in the ten boilers is two hundred and forty square feet, and the ratio of heating to grate-surface is 24 to 1. The boilers are placed opposite each other, five on each side of the vessel, with the fire-room running fore and aft, between them. One telescopic smoke pipe, fifty feet high above the level of the grates, is common to all the boilers.

The arrangement of the coal bunkers differs somewhat in the several vessels of this class, but most of them carry one hundred and eighty tons of anthracite coal; one-half of this amount is stowed behind and around the boilers, and the other half is carried on the berth deck, in bunkers forty three feet long, running on each side of the vessel in the wake of the boilers. Neglecting these berth-deck bunkers, the total space occupied by the machinery and the fuel comprises the whole width and seventy-one feet in the length of the vessel below the berth-deck: the length of the engine room is twenty-three feet nine inches; the length of the fire room forty-four feet, and the width of the space occupied by boilers and fire room, twenty-five feet nine inches from bulkhead to bulkhead.

The coal carried by the *Quinnebaug* (one hundred and eighty tons) is 9.4 per cent. of the displacement of the vessel. The total weight of the machinery equipped for service, including water in boilers, stores &c., is three hundred and sixty tons, or 18.8 per cent. of the displacement. The weight of the machinery is distributed as follows: engines, steam pumps, stores &c., including everything abaft the after fire room bulkhead,=one hundred and sixty-six tons; boilers and all attachments and appurtenances, including floor plates and coal bunkers= one hundred and sixty tons; water in boilers=thirty-four tons. During the steam trial of the *Quinnebaug* in Chesapeake Bay, in December, 1878, a speed of 12.9 knots was maintained for one hour; the highest speed logged was 13.21 knots; but the mean speed for six consecutive hours was 11.65 knots, the engines developing 1102.89 I. H. P. with seventy-one pounds of steam in the boilers, and a combustion of 11.6 lbs. of anthracite coal per square foot of grate per hour.

According to these results a speed of ten knots would require 700 I. H. P. to be developed, and could be maintained with a consumption of seven lbs. of anthracite coal per square foot of grate per hour, or eighteen tons a day, and the vessel could steam at this rate for ten days. In order to maintain a speed of thirteen knots, the rate of combustion would have to be raised to about twenty-three lbs. per square foot of grate. The high speed attained during the trial for a limited period of time, shows plainly that the boilers were deficient in power relatively to the capability of the engines. Their low rate of combustion is to be attributed to the contracted space in the back connections, and to the faulty arrangement of the tubes. The influence of this arrangement on the economic and potential evaporation of these boilers, is discussed

in an article in the last number (March, 1879) of the Franklin Institute Journal.

The draught through the lower tubes is so sluggish, that they become choked with ashes in a short time, and after a few days' steaming, the rate of combustion falls to nine pounds of anthracite per square foot of grate. Another serious disadvantage of the arrangement of the tubes in this boiler is the fact that it renders the crown sheets of the furnace and the bottom of the boiler practically inaccessible for cleaning. This type of boilers seems to have been adopted in order to place them as low as possible in the vessel, and to reduce the weight of water carried by them to a minimum; these considerations, however, must be regarded as of minor importance, compared with the questions of power and durability. The small height under the berthdeck beams of these vessels, barely permits placing boilers one foot larger in diameter into them.

There are building now at the Washington Navy Yard, some cylindrical boilers for the U. S. S. *Nipsic.* They are nine feet in diameter, and are nearly nine feet long. Each boiler has two cylindrical furnaces thirty-four inches in diameter, and contains thirty-two square feet of grate surface. The tubes are arranged in the usual manner over the furnaces, and the boilers are perfectly accessible above and below the furnaces. The ratio of heating to grate-surface is 25.6 to 1, and of grate to calorimeter, 7.08 to 1; with these proportions and a chimney fifty feet high, the rate of combustion with natural draught, ought to be fourteen pounds of anthracite per square foot of grate. Eight of these boilers would contain two hundred and fifty-six square feet of grate-surface, or 6.6 per cent. more than the *Quinnebaug's* boilers, and with the above rate of combustion, they should develop eighteen per cent. more power than the *Quinnebaug's* boilers developed on her trial. At the same time these new boilers would occupy 4.5 feet less room in the length of the vessel; nearly the whole of this space, however, would be required for additional bunker-room, since the greater length of the boilers diminishes the capacity of the side bunkers.

The total weight of these new boilers, fully equipped for service, would be about fifteen tons greater than the weight of the present boilers, entirely on account of the greater quantity of water carried by the larger boilers.

Two rectangular boilers having two hundred and forty square feet of grate-surface in fourteen furnaces, would occupy 18.5 feet less space in the length of the vessel, and would weigh twenty tons less, including

water and all attachments, than the present *Quinnebaug's* boilers. The room saved by the use of rectangular boilers would be sufficient to stow about ninety tons of coal, that is to say double the quantity which the vessel now carries in her hold, or all she carries in her berth deck bunkers. We cannot carry this comparison any farther at present The foregoing may serve as an illustration of the mode of inquiry to be pursued, in determining the relative merits of different types of boilers. In conclusion we will remark, that, whatever our opinion may be about the merits of the compound and simple engines, we cannot shut our eyes to the fact that there is a growing tendency towards the use of higher pressures of steam for marine engines. Necessity will stimulate invention to overcome the serious difficulties which still limit pressures to eighty pounds per square inch. In case further improvements in the manufacture of steel boiler plates, and the discovery of some means which will effectually prevent the present rapid deterioration of marine boilers, should permit the use of a smaller factor of safety in boiler construction, than is at present found necessary, the reduction in weight would be relatively much greater for the cylindrical than for the rectangular boiler. A reduction in the space occupied by the machinery in the vessel can be attained, as far as it depends on the performance of the boilers, only by an artificial increase in the rate of combustion, by means which do not entail a large expenditure of power, or a great decrease in the economic evaporative efficiency of the boilers.

Lieut. Mc Lean. Mr. Chairman. I move that the Institute tender a vote of thanks to Mr. Roelker for the interesting paper he has read this evening.

The motion was carried unanimously.

Lieut. Mc Lean. I would like to ask Mr. Roelker if he has any data or information in regard to the differences in the economic efficiencies of the high pressure boilers with compound engines and the low pressure boilers with simple expansive engines when compared at low rates of speed and medium pressures. I ask the question because I think he has treated only of the high rates.

P. A. Eng. Roelker. I have no data to offer at present which would be valuable. I have endeavored to show in my paper that the economic efficiency of boilers of Naval vessels should not be measured by their economy at the highest rates of speed.

Lieut. Mc Lean. I would like to ask what the life time of these boilers is at 80 pounds pressure? How do they compare in point of economy in five or six years service with rectangular boilers, taking into consideration the high steam pressure required?

P. A. Eng. Roelker. The introduction of compound engines and of these high-pressure boilers into our naval vessels is of comparatively recent date, so that we have not yet sufficient data to say positively what the life time of these boilers will be, in comparison with rectangular low-pressure boilers. Still, there is no reason why the high pressure in itself should cause these boilers to deteriorate quicker. Since the cylindrical form is best adapted to resist internal pressures, and the cylindrical boiler can be made more accessible and all its parts can be adjusted with greater precision to resist the various stresses; I think that the cylindrical boiler, even when used with high pressures, will be found to last longer than the rectangular boiler, provided it be worked under the same conditions as far as corrosion and similar influences are concerned.

Lieut. Tanner. I think that practice has pretty well demonstrated the fact that, in merchant or naval steamers running over regular routes, the cylindrical high pressure boiler has a life equal to if not greater than the rectangular low pressure boiler.

But I wish to ask, Mr. Chairman whether the gentleman does not think that, under the conditions existing in the naval service, where as a rule strange men are put into the fire room at the commencement of a cruise, the life of the cylindrical boiler would be much shorter, relatively, than that of the rectangular low pressure boiler under the management of the same men?

P. A. Eng. Roelker. I do not see why the inexperience of a fireman should shorten the life of our boilers so considerably. One of the principal reasons why the cylindrical boiler has a better chance for life is, that it can be made perfectly accessible in every part. In rectangular boilers there are always a great many narrow water spaces formed by flat surfaces, which have to be stayed every eight or nine inches, and thus access to these parts of the boiler is prevented. Consequently all sorts of deteriorating matters accumulate and rest there. This fact together with the peculiar bending stresses produced upon every part of the shell, is the principal cause of rapid decay, especially at the lower parts, of rectangular boilers. Cylindrical boilers have relatively few such spaces that are not accessible. The interior cannot only be inspected, but can be scraped and cleaned readily. That is a process which does not require especial skill. Therefore I do not see why these boilers should deteriorate more rapidly than the rectangular boilers in the navy, especially when it is proved that they last so much longer or equally as long in the merchant marine.

Of course the cylindrical boilers should be of sufficient diameter to admit of such arrangements as to make all parts accessible. These boilers

in some of our vessels are too small, and made so on account of the low decks, and they are thereby deprived of the advantages I have just spoken of.

Lieut. Tanner. I referred more particularly to the cylindrical boilers, as they are constructed for the smaller classes of Naval vessels, where the space below the beams, and water line, is so small that the boilers can have but little water over the tubes, the evaporation very rapid, the number of boilers greatly increased, each requiring a high order of intelligence and constant watchfulness on the part of the firemen and water tenders, who are enlisted men, and as a rule, strangers to the Engineers in charge, strange to the ship, and that type of boiler—would not the danger of burning out tubes, if not more serious accidents, be greater than with the low pressure rectangular boiler under the management of the same men?

In comparing the relative value of the high and low pressure boilers in the merchant marine and naval service, we must take into consideration the fact that in the former, the leading men in the engine and fire room are usually identified with the boilers from the time they are placed in the ship, and soon become thoroughly acquainted with every detail necessary to their safe and economical management.

Under the present system in the navy, these men are enlisted and sent on board when the ship goes into commission; they are strangers to the Engineers in charge, to the ship, and perhaps, to that type of machinery.

My question is, would not the chance of accident from the burning out of tubes, etc., be greater than with the low pressure rectangular boiler under the management of the same men?

The Chairman. As I understand the question, it is that the complications of the cylindrical boiler are such, that it requires more care to run it than it does in the case of a rectangular boiler.

Lieut. Tanner. The water space in cylindrical boilers as they are constructed for the smaller classes of naval vessels, is much less than in the rectangular boiler; the evaporation much more rapid, the number of boilers much greater, each requiring the same care and constant watchfulness; the men in the fire room at the beginning of the cruise are strange to the ship and, perhaps, to that type of boiler. All these causes tend greatly to increase the liability to accident, and shortening the life of the boiler.

That is the point I make and ask the gentleman if I am not right?

P. A. Eng. Roelker. That is a point to which I think I made allusion in my paper, saying that the multiplication of boilers and of all other attachments naturally produces complications; and certainly on that account there is greater liability to derangement. Of course wherever the machinery is multiplied, the chances for derangement increase. In these vessels, for instance, which I took as an example, we have ten boilers, and even if we increased the size of the boilers to the greatest admissible diameter, we would require eight separate boilers. If we used rectangular boilers, we would put two boilers into the vessel, and there is no doubt that these eight boilers would require four times as much care as the two boilers. Also, these small boilers carry relatively less water than the others, and the water level will fall much quicker than in the larger boilers. Therefore there is undoubtedly a greater chance of accident from this cause; but the number of accidents which have happened on that account, to my knowledge, have been very few; surprisingly few. The coming down of a crown sheet is not a very unusual thing in any vessel. Merchant vessels are just as liable to it as men-of-war. The thing has happened with rectangular boilers as well as with these small cylindrical boilers. No doubt a greater amount of care is required, and liability to accident is increased, as the number of boilers is multiplied.

Lieut. Schroeder. Mr. Chairman, I think it a great pity that we should renounce an improved boiler, one which we think best, and give as a reason why it should not be adopted, that we have not got sufficiently expert firemen to attend to it. I deem that a question that should not be admitted into the argument.

Lieut. McLean. I wish to ask if at ordinary speeds, say seven or eight knots, the compound engine with its boilers as found in our vessels, is more economical, or at least as economical, in fuel, space, and other essentials, as the simple expansive engine with lighter cylindrical or rectangular boilers? Is not the present system better designed for a high speed at an economical rate, than for a cruising speed to be maintained for a long time?

P. A. Eng. Roelker. As to the relative economy of the high pressure compound, and the low pressure single expansive engines, when working with reduced power, there exists still a great diversity of opinion among engineers; and I have not been able to collect a sufficient number of reliable data to settle this question definitely in my mind. For this reason I have spoken, in the paper which I have read, of the efficiency of boilers without reference to the efficiency of the engines proper. I am quite convinced, however, that the selection of the type of machinery for naval vessels should be determined by the relative economy in developing the power required for, what I called, the most efficient cruising speed in time of war; and while the engines should be proportioned with a special view to the *economical* development of *this* power, they must possess sufficient *strength* and *capacity* to work off all the steam which the boilers can generate with their *highest* rate of combustion. The English seem to follow a different course in proportioning the machinery of their naval vessels. They proportion their boilers to steam economically at a low rate of speed, burning about ten pounds of semi-bituminous coal on the square foot of grate per hour; when necessary the rate of combustion of this coal can be increased to twenty-three pounds per hour without the use of artificial draught. But their engines are proportioned so as to work economically with the power due to this high rate of combustion, and in consequence they are wasteful of power and steam at the lower rates of speed, which the vessels have to maintain nearly throughout their whole lifetime. Let us take as an example, the vessels of the *Garnet* class, which are very nearly of the same size as our *Quinnebaug* class of vessels. Their displacement, at load draught, is eighteen hundred and sixty-four tons, or forty-six tons less than that of the *Quinnebaug;* they have, however, three feet more beam than the latter vessel. Their grate-surface is almost exactly the same as that of the *Quinnebaug*, viz.: two hundred and forty-five square feet. The *Garnet* has sufficient height under her berthdeck beams to carry boilers ten feet in diameter, and of these she requires only six, while the *Quinnebaug* has ten boilers, eight feet in diameter, on account of the small height under her berthdeck beams: for this reason, the boilers of the *Garnet* occupy eleven feet less space in the length of the vessel than the *Quinnebaug's* boilers. But the engines of the *Garnet* are much larger than those of the *Quinnebaug*, and, apparently, proportioned to work economically, when developing the highest possible power, viz.: twenty-one hundred indicated horsepowers.

The *Garnet* has two-cylinder compound engines.

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| Diameter of high pressure cylinder, | 57 inches. |
| Diameter of low pressure cylinder, | 90 inches. |
| Length of stroke, | 33 inches. |
| Steam pressure in boilers. | 60 lbs. per sq. inch. |
| Highest number of revolutions, | 90 per minute. |

The main dimensions of the *Quinnebaug's* engines are as follows:

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|---|---|
| Diameter of high pressure cylinder, | 42 inches. |
| Diameter of low pressure cylinder, | 64 inches. |
| Length of stroke, | 42 inches. |
| Steam pressure in boilers, | 80 lbs. per sq. inch. |

English engineering journals have criticized severely this policy of the English naval authorities, of proportioning the engines of their vessels for a power which can be developed only under the exceptionally favorable conditions of a trial, and which will rarely be approached in the whole afterlife of the vessel.

Lieut. JOHN H. MOORE. Mr. Chairman; Mr. ROELKER has stated that European navies use semi-bituminous coal in their vessels. I would like to ask if any better results would have been obtained in the recent trials of the *Quinnebaug* if this semi-bituminous coal had been used.

P. A. Eng. ROELKER. More power would undoubtedly have been developed, but the boilers have not the proportions required for the economical use of semi-bituminous coal. This coal experiences great waste and deterioration from transportation and long stowage, and produces much soot which lessens, often greatly, the heating efficiency of the boilers. But for a short trial of speed the use of that coal gives much better results than anthracite. The difference is this, as I have already stated; under the most favorable circumstances, the boilers being constructed with a special view to attaining a high rate of combustion, not more than sixteen pounds of anthracite can be burned on the square foot of grate per hour, with natural draught; while twenty-three or twenty-four pounds of semi-bituminous coal are always burned during the full-power speed trials of English vessels.

Lieut. MOORE. During the trial of the *Quinnebaug* did she have any means of obtaining artificial draught from a jet or fan?

P. A. Eng. ROELKER. That I am not quite sure of. Some of the boilers were designed to have a steam jet, but whether they were all supplied with it I cannot tell. There were no fan blowers. In such trials jets are not made use of, because too large an amount of steam would be expended. All the trials which we make, are made with a natural draught in order to test the capabilities of boilers and engines under ordinary conditions; in fact, that is the difference between the trials of our engines and those of the English service. They test their vessels under exceptional conditions; we test ours under the ordinary conditions of service. The English use a fuel that is specially selected for trial purposes. It produces only about six per cent. of refuse, being hand-picked and delivered in the most perfect condition on board the vessel. The firemen have only to throw it into the furnaces and keep the fires properly leveled. A special body of men is selected from the Reserve to do duty as firemen during each trial. Our vessels as soon as they are ready for a cruise, with their stores aboard, steam out with the ordinary coal which is to be used during the cruise. The coal used during this so called full-power speed-trial may be good, bad or indifferent. The firemen, also are generally newly enlisted men, and often possess little experience and skill in firing. On this account we may say that actually we do not even try our vessels under conditions as favorable as obtain ordinarily in the service, because the men profit by their experience in the course of a cruise.

Our naval vessels on foreign stations very often use Welsh coal and I think it would be a good plan for our vessels to try the mixed fuel which is used in the English and French services; that is a mixture, in equal proportions, of this Welsh and of bituminous coals. The bituminous coal acts in binding the small particles of this Welsh coal together and thereby prevents waste of coal through the grate. But whether the substitution of this semi-bituminous coal for anthracite for general cruising purposes would be an improvement, it is hard to tell at present.

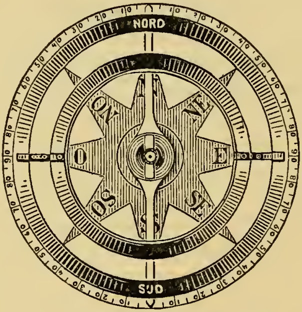
Rear Admiral JENKINS, (Vice President.) While in China, we used the Cardiff or Welsh coal in our ships and we found that the British Admiral in charge of the British Squadron in China, bought a lot of it for the sake of economy. We also used the Japanese coal, called Takasima, and found it cheaper than our own coal.

## PROFESSIONAL NOTES.

These articles not having been read before the Institute are inserted by direction of the Executive Committee.

* * * The Duchemin Compass.* "The ordinary compass needle offers to the two magnetic currents of the earth, a surface merely narrow and longitudinal. Reason tells us that the greater the surface which the compass offers to the immense action of terrestrial magnetism, the greater and more positive will (other things being equal) be the resultant effect. This thought has been on my part the object of long meditations, and I have had the idea of creating, by utilizing the artificial currents which we possess, and by conceiving a new process of magnetization, *the magnetized circular bar* or circle with two magnetic poles at the extremity of the same diameter. This magnet possesses two neutral lines, which give a complete surety against the displacement of the magnetism; the figure obtained by means of iron filings placed above the magnetized ring, attests the perfect distinction of the magnetism in the circle.

From this idea has arisen the compass with a circular needle, whose conception was at first received with marks of profound incredulity and irony.




Duchemin's Compass †

with two concentric circular needles and steel traverse connecting the poles. The maximum magnetization is at the North and South points respectively, decreasing to zero at East and West, as shown by the shading upon the circles.

* Extracts from "Experiences Pratiques de la Boussole Circulaire, faites a bord des Navires de l'Etat et de la Marine Marchande. Adoption de cet instrument sur l'Escadre. (Huitiéme Édition: Revue et Augmentée). Par Emile Marin Duchemin, Laureat du Congres International des Sciences Geographiques de 1875," by Allan D. Brown, Lieut.-Comd'r. U. S. Navy.

† I am indebted to Cadet Mid'n. Hunicke, U. S. Navy, for the admirable drawing from which this electrotype has been made. A. D. B.

The circle, magnetized by a special process which gives magnetic stability, placed upon a pivot, or suspended by a thread from its center, constitutes a true compass, the north pole pointing to the south, the south pole to the north. The poles being considerably farther apart than in the ordinary straight needle, the terrestrial attraction is consequently multiplied. Further, the circle forming a symmetrical figure about the point of suspension, its mechanical stability is greater; the mass acted upon by terrestrial magnetism being thus augmented, it is clear that the oscillation of the nautical circular compass is less uneasy under the blows of the sea, than that of the ordinary straight needle. From these different points of view, the circular compass is deemed as a true step in advance, which the trials at sea have fully confirmed.

To give an idea of the magnetic force of this instrument, (a force which can be augmented by the addition of concentric circles, and of a traverse of steel, itself magnetized and forming an armature) I will add that a circular compass of $20^{dcm}$ in diameter, caused in an ordinary needle a deviation of from 45° to 70°; under the same conditions the ordinary needle caused a deviation of but 17° or 20°.

### Experiments on board the *Faon*.

These were divided into two series: first those upon the ordinary compass designed to ascertain the value of the circular compass when placed under the same circumstances as the former; second, those looking to the correction of local influences by the addition of a movable concentric magnetized circle. For the first series an ordinary mariner's compass, having a needle $20^{dcm}$ in length, previously magnetized to saturation, was compared with a magnetized circle of the same exterior diameter; the two compasses were placed under the same conditions as to pivot and agate. Following are some extracts from the report.

'*Sensibility.* The sensibility of the circular compass leaves nothing to be desired: it is superior to that of the ordinary needle. Removed from the magnetic meridian, the circle returns more quickly than the needle, although the friction of the first is greater, since the weight of the entire system is one hundred and forty-one grammes, while that of the ordinary card is but sixty two. It may easily be conceived that it may be possible to store up in a circle more magnetism than in a bar, and that with equality of weight. By simple inspection of a magnetized circle this may be comprehended; besides a needle magnetized to saturation allows the fluid to escape at the ends, if it is desired to charge it more: it is not the same with a circle.'

The report establishes the fact that the concentric circle augments the sensibility of the circular compass while giving it additional direct-

ive force. To my mind this circle has another advantage; it seems to correct the time or the length of the oscillations, that is to say, if a compass with one circle gives a period of four minutes of oscillation, the second circle will by its presence diminish about one-half the duration of this period. I can say with the report, that during all our passage, with a smooth as well as with a rough sea, we have never found the circular compass *asleep;* and that the helmsmen have been able to detect the slightest variation of the course by a simple inspection of the card.

'*Mechanical Stability.* The oscillations of the circular compass about its position of equilibrium, are less than those of the ordinary card; this may be seen, *a priori*, by reason of the equality of the moment of inertia in every respect.'

With the ordinary compass this equality is obtained by utilizing additional weights, or by means of a complication of bars which augments the weight of the instrument: but is this not to the detriment of the directive force?

In the circular compass this equality of inertia exists of itself, and the parts of the circle which contribute to its mechanical stability contribute also to its directive force: this fact is incontestable. I find its proof in the employment of a plated brass circle by certain constructors: this circle is not, in the opinion of sailors, applied to the compass without great detriment to its directive force.

'Evidently, like the ordinary compass, the circular compass oscillates with the rolling of the vessel; but its oscillations are slow and are not to be compared with those of the former. The vessel rolling greatly in a heavy sea, the helmsmen take their bearings without any uneasy movements of the compass.

In a smooth sea, the liquid compass sleeps in a lazy manner, while the circular compass has a stability almost equal to that of the other, and a sensibility very superior to it.

*Magnetic Stability.* The stability of the circular compass is very satisfactory: drawn from the magnetic meridian on account of the rolling of the vessel (when the masses of iron on board acquire a polarity ever changing with the roll) the number of its oscillations is much less than that of the ordinary compass: like the light card, for smooth weather it is excellent, for it does not sleep: like the heavy card, for rough weather, it presents a mechanical stability which should lead to its preference over the common compass.'

*Coincidence of the axes.* In his statement, the author* of the report from which these extracts are taken, asks if the inventor does not ex-

* M. le capitaine de frégate Felix Le Clerc.

perience serious difficulties in localizing the magnetism at the desired points, where the constructor indicates by marks the north and south points of the circle. The magnetization of the circle is very simple: it is performed instantaneously by means of a bar of soft iron designed by myself and constructed by M. Ruhmkorff, who has lent me the most assiduous aid and without whose skill it would have been very difficult for me to establish my circular compasses. Hence I affirm there is no difficulty on this point.

'It is conceivable that there is no definite reason to fear that the poles will be displaced, if it be considered that there exist two neutral points whence the magnetism begins at zero and is concentrated at the poles of maximum strength. There exists no reason why these neutral points should become magnetized, and hence the stability of the maximum poles.'

The report goes on to say that I have presented two kinds of circular compasses, in one of which the steel ring is supported by a traverse of aluminum, while in the other the traverse is of magnetized steel. The fact is recognized that both these compasses function perfectly: but the opinion is expressed that it would be better to adopt the steel traverse, whose poles coincide with those of the circle of the same name, for it is natural to think that the polarization of the circle will be maintained in preference to the points where the trace of the magnetic axis of the needle cuts the ring. Thus the armature system seems to have the greater weight with the author of the report.

But, in order to go farther than the objection which has been made, I have placed above the point of suspension a small magnetized needle with poles reversed. The axis of suspension of this small needle coincides with that of the circle; its magnetic axis naturally takes its place in the direction of the diameter of the poles and follows it invariably with remarkable energy and fidelity. If the magnetic axis, or rather the magnetic diameter, of the circle does not coincide with the axis of figure which ought to pass through the north and south points marked upon the card, the small needle will indicate it. One will always be warned against an accident, which is less to be feared with the circle than with the needle.

'To sum up, the circular compass is an instrument worthy of all attention from the navigator. By perfecting its practical construction and by placing the circles under a card of isinglass, we shall have an instrument, sensible and stable and one which will constitute a true step in advance. There is the very desirable power of augmenting its magnetic stability and sensibility by the addition of concentric circles without changing the equality of the moment of inertia in any respect, and without fearing (as in the

compass with several needles) the influence of the neighboring poles, which has a tendency to destroy the magnetism.'

The idea of correcting the deviation of the compass by the displacement of one of the concentric circles of the circular compass appears to me to be untenable; for, from observations made at sea, I am persuaded that the cause of the phenomena which it is necessary to overcome being due to divers exterior actions, any interior disposition of the instrument, however ingenious it may be, will prove insufficient. Experience has shown that the circle behaves like the straight needle. Nevertheless, the circular compass has some advantage over the ordinary one, as the report recognizes, with regard to its deviations, on account of their greater regularity; its greater magnetic energy making its indications less subject to accidental errors. As the poles are placed symmetrically about the point of suspension and are separated by a greater extent than in the straight needle, the terrestial action is consequently multiplied. By displacing the interior movable circle about its axis there is obtained, it is true, an action which corrects for a single course, but at the same time there is created so to speak a new instrument, whose magnetic direction is the resultant of the action of the two contrary poles. This new instrument is submitted to local deviations which are not sensibly lessened.

'By swinging the vessel at the compass buoys in Cherbourg harbor the circular compass has enabled us to detect errors in the construction of the deviation table, errors due to the want of energy and precision of the liquid compass. Upon this last point the circular compass leaves nothing to be desired.'

EXPERIMENTS ON BOARD THE IRONCLAD *Savoie*.

'The Duchemin compass has a magnetic power much more considerable for the same mass than one of our ordinary compasses. This power is from two to four times greater than that of those which have been experimentally compared with it. It has then over our own compass the advantage of much greater sensibility.'

This report suggests the application of the circular needle in the liquid compass.

Such, concisely stated, are the results which the new compass has given at sea. I will add that the personal study which I have made of the compass with circular needles leads me to believe that the extreme sensibility which can be given to this instrument might be advantageously utilized in our meteorological observatories.

EXPERIMENTS ON BOARD THE *Duchaffaut*.

'The magnetic compass of M. Duchemin has a much greater magnetic

power than the regulation compass which we have on board, which makes it more fixed and causes its local deviations to be less than those of the other.

The results obtained on board this vessel by comparing the two compasses, placed successively in the same binnacle and under the influence of the same causes of deviation, are in favor of the Duchemin compass. Compared with a liquid compass it is less mobile and its relative steadiness gives more facility in taking bearings at sea. * * * *

I find your compass less mobile than those of the ordinary pattern; that is to say, that it is deranged less upon any given course because it has a greater magnetic attraction and because its poles remain in the magnetic meridian with greater persistence than those of the ordinary ones.'

EXPERIMENTS ON BOARD THE TRANSPORT *Orne*,

with a new circular *liquid* compass, during a voyage of circumnavigation.

'By an order of the 26th and 29th of May, 1875, the Minister of Marine directed comparative trials of different compasses to be made aboard the *Orne*.

The compasses experimented with were,

Ritchie's American compass with two needles and floating circle.

Duchemin's circular liquid compass.

Regulation Azimuth compass with single needle.

| | | | | |
|---|---|---|---|---|
| Regulation | do | do | four needles | (light card.) |
| do | do | do | do | (heavy card.) |
| do | Liquid compass with two needles. | | | |

The Dumoulin-Troment liquid compass with card, mounted with a Laurent circle.

The Dumoulin-Troment liquid compass with two needles in lozenge with additional segments in brass.

The programme for the trial of the Duchemin compass indicated three points to be observed; fixity of the line of the poles; sensibility; mechanical stability.

*Fixity of the line of the poles.* The Duchemin compass observed during the whole voyage concurrently with the various others always showed the greatest stability of magnetism: on the night of the 23 August, 1875, during which a violent storm raged unceasingly, a thunderbolt fell at some distance from the vessel, at the same time that a brilliant St. Elmo's fire at the peak of the spanker gaff attested the highly electric state of the surrounding atmosphere. Experiments made the succeeding day, demonstrated that the Duchemin compass had not in any way been influenced by the electricity in its vicinity. Observed daily, while by the vessel running perpendicular to the isoclinic lines it was subjected to continual changes in its induced magnetism, this compass showed no displacement of the line of its poles.

Upon arriving at New Caledonia, different articles of iron (boilers, pieces of machinery, etc.,) were landed: other articles (guns, etc.,) were embarked and placed in different positions from those the others had occupied.

The compass was submitted to violent shocks; among others a fall which broke one of the gimbals; it was frequently removed from aft to the bridge, and was allowed to remain upon the bridge at 0.$^m$ 5 from an iron stanchion, at 3$^m$ from the galley funnel and at 2.$^m$5 from the smoke stack which was sometimes up, sometimes down, sometimes hot and sometimes cold. In either case the fixity of the line of the poles showed no alteration.

Polar auroras produced not the least perturbation. In New Caledonia the *Orne* passed through the Wodin strait, a narrow passage between ferruginous mountains: the deviations shown by this compass were not different from those of the others. Finally, as opportunity offered, the deviation tables were examined as a verification of the fixity of the line of the poles. This compass has shown in its deviations some differences from those of the steering compass, but they are so small that they may be ascribed to errors of observation.

*Sensibility.* The Duchemin compass possesses this quality in the highest degree: in calm weather it shows rapidly and almost instantaneously the slightest deviation from the course. Its magnetic power is quite great; when the vessel changes her course, the card appears perfectly independent and turns without the least inclination to follow the vessel's head, either on account of the resistance of the liquid or the friction upon the pivot. In point of sensibility, this compass appears to be excellent; its qualities of stability are not less remarkable.

*Stability.* Whether the engines turn at a high or low speed no effect is visible upon this compass; there is no violent motion, no trembling. This property it has in common with other liquid compasses. When the vessel is moved by the sea in calm weather, that is to say when the rolling motion though considerable, is regular, the Duchemin compass follows the rolling with an extremely small retardation in its oscillations, and the movements of the card cease almost as soon as the rolling motion.

That is to say, on board the *Orne* with a roll lasting from 5.5 seconds to 6 seconds, this compass has its line of poles carried successively to starboard and port in the same interval of time, but without any accumulating impulse, and this whatever be the heading of the vessel. In this way the amplitude of the oscillations due to the rolling are always restrained and rapidly arrested, which proves at the same time the great magnetic power as well as the excellent stability of this compass. In bad weather, when the vessel is violently tossed, the movements sharp, the recovery quick, the pitching violent, the Duchemin compass shows excellent qualities. Sometimes, but rarely, the card surprised by a sudden movement of the vessel takes up a notable jumping motion, but it never becomes greatly excited: its movements soon cease and it takes up rapidly its mean position and feeble motions. Sometimes, in a heavy sea, when it was impossible to take the bearing of the sun with the ordinary azimuth compass with a single needle or even with the heavy card with four needles, the Duchemin compass was successfully used.

To sum up, this compass, on account of its great magnetic power, by reason also of the property which it possesses of having the same moment of

inertia upon all courses, is less affected than any other by different disturbing causes. All questions of detail apart, the Board is of the opinion that among all the compasses experimented with, the Duchemin compass, thanks to its superior magnetic power, appears to be the most serviceable.'

On board the *Dupleix*, during a voyage to Iceland, experiments were made and the Board reported in much the same manner as the officers of the *Orne;* they close their report by saying, that

'They are of the opinion, that under all circumstances of wind and sea, whether under sail or under steam, the Duchemin circular compass is superior to the ordinary compasses in use. In particular they have appreciated its sensibility in the northern regions which the *Dupleix* has visited during the voyage, regions in which the ordinary compass has a very decided tendency to insensibility.'

On board the *Laplace*, in 1876,

'On the 4th of May while lying to in a gale, and on the 11th of October, while scudding, the amplitude of the oscillations of the ordinary compass exceeded a point and a half; while the oscillations of the Duchemin compass were barely more than a quarter of a point, which permitted a course to be kept, a thing impossible to be done with the ordinary compass.'

On board the iron-clad *Atalante*, during a cruise in the Pacific,

'The Duchemin compass showed itself always superior to the binnacle compass with which it was compared; its oscillations have never exceeded *two* degrees, while those of its neighbor were as great as *eight* or *ten* degrees.'

The compass on board the *Duchaffaut*, (previously spoken of) was one of the first constructed, and was afterwards placed on board the *Corrèze*, and was highly commended in the report of the Board which was ordered to experiment with it.

The liquid compass which was on board the *Orne* was afterward placed on board the *Cosmao*, and her commanding officer was as much pleased with it as were the officers of the first named vessel.

'On board the ironclad *Richelieu* there were two Duchemin compasses. One was an azimuth compass, placed in the forward conning tower, under the eye of the officers of the watch, about $3^m$ from the smokestack, and $2^m$ from the electric apparatus which shows the course at night; $2.^m5$ below and $2^m$ one side are situated two turrets each containing a 15 ton steel gun. The other was a binnacle compass placed in the tower near the steering wheel, a little forward of the first one and about $4^m$ from it, and about $1^m$ from the midship line. These two compasses are more sensitive than any of the others, notwithstanding the vicinity of these great masses of iron.'"

NOTE. The Duchemin compass has been adopted as the regulation instrument in the French Navy, and by various lines of merchant steamers.

A. D. B.

## LIST OF MEMBERS

who have joined the Institute since the publication of the last report.

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ALLDERDICE, Ensign W. Hagerstown, Md.
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BEARDSLEE, Commander L. A. Navy Department.
CARTER, Commodore S. P. Navy Department.
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EVANS, Commander R. D. Commanding Saratoga.
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# PRIZE

AND OTHER ESSAYS.

1879.

WASHINGTON, *March 22, 1879.*

SIR,

The undersigned, to whom were submitted in January last ten essays on Naval Education, with the request that they decide which is the best and which of the others deserve mention for merit, have the honor to report—

1. That they consider the essay with the motto "*Qui non proficit, deficit*" to be the best.

2. That they think the two essays bearing respectively the mottoes "*Esee quam videri,*" and "*Essayons*" to deserve honorable mention in the order in which the mottoes are here placed.

It will not be supposed that the undersigned accept and approve all the opinions and proposals contained in the essays which they have preferred. The three essays which they distinguish seemed to them the most thoughtful and suggestive in substance, and the clearest, simplest and most accurate in style.

They beg to add that the competition for the prize offered by the Naval Institute has evidently been an animated one, and has called forth a creditable amount of strenuous exertion.

Your obedient servants,

CHARLES W. ELIOT,
*President of Harvard University.*

DAN'L AMMEN,
*Rear-Admiral, U. S. N.*

W. H. SHOCK,
*Engineer-in-Chief, U. S. N.*

Lieut. JOHN C. SOLEY,
*Secretary of the Naval Institute.*

THE RECORD

OF THE

UNITED STATES NAVAL INSTITUTE.

# NAVAL EDUCATION.

By Lieutenant-Commander Allan D. Brown, U. S. Navy.

*"Qui non proficit, deficit."*

## I.—Officers.

The question of Naval Education is one that is fraught not only with the improvement of that branch of the public service, but, in the event of war, with the honor of the entire country; and it therefore merits the gravest attention from those authorities to whom the welfare of the Navy is committed.

The necessity of a more liberal education for the officers was early seen by the officers themselves; and it is not only to the Hon. George Bancroft, Secretary of the Navy, that we owe the establishment of the Naval Academy at Annapolis; but to Commodores George C. Read, Thomas Ap-Catesby Jones, Matthew C. Perry, and Captains E. A. F. Lavallette and Isaac Mayo, for their hearty approval of the scheme. Nor should the name of Commander Franklin Buchanan be ignored in this connection, for to his admirable administration of the trust committed to him as its first Superintendent, is undoubtedly due the continuation of the School after its first tentative establishment.

The question as to the system to be pursued in the education of the Naval Officer is one that may still be considered an open one; that *some* sort of an Academic course is necessary is generally admitted, but whether this course should precede or follow a course of instruction afloat is not yet satisfactorily settled. I believe that the present system, in which the student is placed under strict discipline on shore at the outset of his career, is preferable to that which would permit him

to be subjected to the temptations incident to a sea life, before his character and habits are sufficiently formed to enable him to withstand them successfully. One great objection to it, however, is the fact that but few ships can have Midshipmen on board, as the whole number of officers of that grade is necessarily small. While admitting that the Midshipman fills an office which is of great use to the discipline of a vessel, yet we must not lose sight of the fact that it is not *Midshipmen alone* whom we seek to train, but the Commanders of the Navy of the future. And in the education of the men, we must take care that the want of the Midshipman of the olden times be not greatly felt, by committing to intelligent petty officers many of the duties heretofore performed by officers of that grade. Assuming, then, that the Academic course is that to be first pursued, it becomes necessary to define clearly what officers are to receive this instruction. The officers of the Navy are divided by law into Line and Staff; the latter being subdivided into Medical, Pay and Engineer officers, Chaplains, Professors of Mathematics, Naval Constructors, and Secretaries. Included also in the Naval organization are the officers of the Marine Corps.

From any scheme of purely Naval instruction it is obvious that the Medical officer must be excluded; his preliminary training must be obtained in some established Medical College. The Chaplains also and the Professors of Mathematics (together with the Secretaries whose offices will become vacant with the lapse of the offices of the Admiral and Vice-Admiral) are also not to be included. There remain, then, as the officers who are to be trained at the Naval Academy, the officers of the Line and of the Marines, together with those of the Pay and Engineer Corps and the Naval Constructors. At present we have only the Line and Engineer officers under such instruction; how shall we bring in the remaining officers in such a manner as to conduce to the harmony of the service and the good of the country?

The subject thus presented for discussion involves not only the manner of the education of the officers above mentioned, but also the number required to undergo such instruction, as well as the manner in which the requisite number shall be selected.

Before entering upon the discussion of these points, it will be desirable to look first at the requirements of the ideal Naval Officer of today in the way of education: and it must be the aim of the authorities to approach as near the ideal as possible: the country both needs and desires the best that can be procured. The progress of modern scientific ideas has rendered an extended curriculum necessary; the

introduction of steam propulsion (much as we may regret its destruction of the romance of the sailing frigate) has made it necessary that the Naval Officer should not only know how to *sail* his vessel, but how to *steam* her, in the most judicious and economical manner. He should understand thoroughly the working of the motive power of his ship, and he should be as able to run the engines, to tend the fires, or to put a patch upon the boiler, if necessary, as to reef topsails or to splice a rope. He must, perforce, be a navigator; by which term is implied not only the ability to keep the reckoning of the ship from day to day, but also to handle his vessel skilfully in waters unknown to him except by means of charts; and furthermore, a skilful navigator should possess such knowledge as will enable him to make a chart of unsurveyed ports, or to replace the buoys and beacons in a harbor, which may have been removed by an enemy or otherwise. The introduction of iron in shipbuilding has rendered necessary a thorough knowledge of the deviation of the compass, a branch of navigation which was formerly of but very slight importance, but which now assumes a great deal of consequence. He must be an artillerist; he must understand the manipulation of the weapons provided for offence and defence on board his vessel; he must have such a knowledge of torpedoes, of their construction and use, as to enable him to make this terrible engine of war do useful service against an enemy, or to avoid those that may be brought to bear against himself. He must also have a sufficient knowledge of the soldier's profession to enable him to train his own men, and to qualify both himself and them for expeditions on shore, where he may be called upon to protect the property of American citizens or to take active offensive measures against an enemy. He must possess a sufficient amount of legal knowledge to qualify him for a seat upon courts-martial; and he must also be sufficient of a diplomat to enable him to decide promptly and correctly, questions which involve the honor of the flag, as upon his action may hang peace or war. He must, of course know how to handle his vessel, of whatever type she may be, whether monitor, iron-clad frigate, or wooden gunboat, under all circumstances of wind and weather, as also of battle; to which end he must understand the signals that may be made by his chief, and the method of the execution of the orders thus transmitted. He must be fertile in resources in cases of emergency and disaster; and quick to appreciate the worth of the changes that are constantly taking place and being proposed in the fitments of vessels. To all these varied requirements must be added the habits of obedience and command, and

that ability to impress his individuality upon those placed under him, which alone can render him successful in the crucial trial of battle, for which indeed his whole education must be a preparation. Such, I say, is the *ideal* Naval Officer; it should be the aim of each to approach as near to the standard as his individuality will permit; the country wants, as I have said, the *best*, and it is our duty to see that so far as in us lies we give to her our efforts to come as near the best as we can.

That these requisites of the Naval Officer, so far in advance of those of former days, are due to the introduction of steam into ocean navigation, will, I think, be at once acknowledged; this power, which was at first deemed only an auxiliary, has become the *primum mobile*, and we cannot shut our eyes to the fact that there is now necessary a complete knowledge of the new *steam seamanship*. Attributing the highest importance to this factor in the man-of-war of to-day and of the future, I consider it necessary that the distinction now existing between the Line officer and the Engineer officer be greatly modified and soon be practically abolished. I am aware that such a radical change would not only meet with great opposition at the outset, but would be very difficult of speedy accomplishment. I am sure, however that it *can* be accomplished; and the details of the system which I propose to this end will appear further on.

Let us return now to the question of the number of officers to be educated: this is a matter of great importance, as, while it is desirable that enough new men should be coming forward each year to keep the ranks full, any overplus is to be deprecated.

The annual number of graduates of the Naval Academy requisite for this purpose, might be found by taking, as the maximum number to be allowed each year, the actual number of vacancies existing in the active list at the expiration of the second year of the course as indicated hereafter.

In this country it is a matter of importance that the equal chance which all classes of our fellow-citizens have under the present system, should be maintained. To this end I believe that the present method of appointment by Representatives in Congress is the best, but there should be an additional provision of law that these appointments should only be given to those who are successful in a competitive examination, held after due public notice. It might perhaps be wise for the Secretary of the Navy to send to each Representative having an appointment, the scheme of an examination; such scheme to be prepared by the authorities of the Naval Academy. This would tend to

uniformity of standard throughout the whole country. These appointments should be made from each district in alternate years; and the appointee should be sent to Annapolis to be again subjected to an examination, in the same manner as is now practised. In this connection I would urge that the number of appointments-at-large by the President might be advantageously restored to the old number of ten each year, with the limitation that these appointees should be from the sons of Army and Navy officers, thus opening an opportunity to them which is now entirely closed, as an officer is continuously on the move and generally has no fixed residence in any congressional district to entitle his son to compete. If the candidate passed the entering examination he should receive an appointment as NAVAL CADET, and should undergo substantially the same course as is now pursued at the Naval Academy for the first two years. At the expiration of that time those men who stood highest in their class (within the limits of number as fixed according to the preceding method) should receive their appointments as MIDSHIPMEN, and should be then deemed to have entered the Naval service. Those who fell without this number should receive certificates showing that they had passed through the preparatory course, and should also be given (unless deemed specially unworthy) honorable discharges as Naval Cadets. This is substantially the plan advocated by Rear-Admiral C. R. P. Rodgers, late Superintendent of the Naval Academy, from whose report to the Secretary of the Navy for 1877, I quote the following:

"In my opinion the number, both of cadet-midshipmen and cadet engineers, might be advantageously decreased. During the present winter, for the first time, the list of ensigns will be filled, and midshipmen who shall have passed their examination for promotion to that grade must wait for new vacancies before they can reach it. Under our present system, this number of passed midshipmen will increase every year, and we shall have the sorry sight of an ever-increasing number of young gentlemen—two, or perhaps ten, years after their graduation—waiting, with hope long deferred, for promotion to the lowest grade of commissioned officers.

"We shall, also, under the present system, graduate every year many more cadet-engineers than will supply the waste of that corps. I would, therefore, respectfully suggest that either the number of cadet appointments be largely decreased, or that a new system should be adopted which would produce far better results than the one now in force.

"I would suggest that some able actuary be found to calculate the

annual waste of the Navy, both of the Line and of the Engineer Corps; and, further, that he should compute how many cadets should each year enter the second class to supply that waste, and keep the number of officers in the lower commissioned grades of the Navy always full.

"This table could be made more easily than the tables of the life insurance companies, and might be re-arranged every five or ten years. The number of cadets for the second class being thus decided, admission to it should be the prize for which all entering the Naval Academy should compete during the first two years of their novitiate. Those who failed to win the prizes might be graduated at the end of their first two years, and return to their homes with an honorable diploma, and would well repay the country for the cost of their training, by carrying to every congressional district in the land the habit of discipline, the traditions of military life, and a practical knowledge of the use of arms, which would make them invaluable in the organization of volunteer regiments whenever the country found occasion to call its citizens to arms.

"There is a subtle power in military discipline which cannot be readily defined, but which gives to those who have learned to obey, a great capacity to command with ease and with ready acceptance. Under this system no cadet need be found deficient, except for grave misconduct or for contumacious and inexcusable neglect of study." * *

It must be borne in mind that under this scheme we are to educate not only the future Line officers of the service, but also the Engineer, Marine, and Pay officers as well as the Naval Constructors; consequently it is very desirable that the course should be the same for all the cadets during the course. At present the course for cadet-midshipmen and cadet-engineers during the fourth and third class years is almost identical; a little judicious trimming, with but little loss in any particular direction, would render them precisely the same. If the new appointees should enter in May, they might embark at once on board the practice ship for the summer cruise, and so gain an additional amount of experience, by having two cruises during the first two years, instead of one, as is now the case. Besides the sailing practice ships, there should also be a suitable practice steamer attached to the Naval Academy; and opportunity should be afforded to the cadets to perform fire and engine-room duties during their third class year, prior to the beginning of the summer cruise.

Under the system of selection herein advocated the school would contain no more students than at present, so that the expense of the increased number of appointments made would be nothing; the difference

would be that the preparatory classes of Naval Cadets would be very large, while the upper classes of Midshipmen would be very small, and would be composed of the best men who entered in each year.

With the date of his appointment as Midshipman, the education of the officer would really begin. After the two years of his preparation as a Naval Cadet, spent within the walls of the Academy, he would be more enabled to appreciate his advantages, especially as he recognized the fact of his selection from the large number who entered with him. Inasmuch as each class would be composed of the best material, it would be possible to pursue a higher course in all branches than is now pursued at Annapolis; and by the addition of one year to the course, *every* student could be instructed in all the branches now taught to both cadet-midshipman and cadet-engineer; and each man would graduate for service in the fleet with a greater degree of competency for duty, either on deck or in the fire and engine-rooms, than that now possessed by either class of young men who leave the school after a four years course.

With his entry upon the larger stage of action afloat, would begin for the young officer his instruction in the command of men, and in the ordinary routine duties of ship life. Care should be taken to have a sufficient number of Midshipmen on board each ship to which they might be ordered to perform duty both on deck and in the engine-room; and during the cruise of two years, they should, as now, be preparing for their examination, upon successfully passing which they should be at once commissioned as Ensigns and become Ward-Room officers. At this point of his career we should have the young officer fairly prepared for his future duties, after a course of preliminary training lasting seven years: he would have a thoroughly good foundation upon which to build any speciality to which his natural disposition inclined him; and while he would not lose his identity with the Line, he could avail himself of the opportunity offered to apply himself to further improvement in any direction he saw fit. Before proceeding to the consideration of the later education of the officers, I present the following scheme for that of the first seven years.

### Course of Instruction.

*For all Classes.*—Practice Cruise, June to September, inclusive.
Academic Year, October to May inclusive.

*Naval Cadets.*

*First Class, First Year.*—Practice Cruise, Mathematics, English Studies and History, French, Drawing.

*Second Class, Second Year.*—Practice Cruise, Mathematics, History and Rhetoric, Physics, Chemistry, French, Drawing.

At close of this year selections made for appointment as—

*Midshipmen.*

*Third Class, Third Year.*—Practice Cruise, Seamanship, Ordnance, Marine Engines, Applied Mathematics, French, Mechanics, Spanish.

*Junior Class, Fourth Year.*—Practice Cruise, Naval Construction, Ordnance, Navigation, Heat, Light, Spanish, Astronomy, Marine Engines, Drawing.

*Senior Class, Fifth Year.*—Practice Cruise, Navigation, Surveying, Fabricating Machinery, Strength of Materials, Designing Machinery, Public Law, Physical Measurements, Naval Tactics.

Practice Cruise of First, Second, and Third Years, to be in sailing vessels.

Practice Cruise of Fourth Year in steamer, visiting ship-yards &c., &c.,

Practice Cruise of Fifth year in sailing vessels.

Practical Exercises during the Academical Year in Seamanship, Naval Tactics, Infantry, Field Artillery, and Boat-Howitzer Drills; Great-Guns, Mortar Practice, Manipulation of Artillery on board Iron-Clad, Fencing, Marine Engines, Management of Boilers, Tools, and Machines, &c., &c. Leave should be granted for two months in the third practice cruise, and for one month in the fourth.

At the end of the fifth year, graduation, followed by leave for three months; at the expiration of which the graduates should be ordered to sea for two years. During this time they should be given duty both on deck and in the engine-room, and should also have especial attention paid to their instruction in practical Navigation and Seamanship.

The number of graduates in each year would be very few (not exceeding twenty-five.) Three ships would provide duty for them all, and the Commanding officers of these vessels should have special instructions with regard to the Midshipmen, so that all might have equal opportunities. At the expiration of the cruise the examination for Ensign should be held.

Having thus obtained the lowest grade of commissioned officer, before proceeding to the question of post-graduate education, it will be necessary to detail the scheme already foreshadowed with regard to the amalgamation of the various Corps.

I assume the broad principle that (with the exception of the Medi-

cal officers and the Chaplain) *every* officer on board ship should be a combatant sea officer, a graduate of the Naval Academy, an efficient addition to the strength of the ship's company, in lieu of the present plan, by which many persons of the ship's complement are unskilled and untrained in the use of arms; and this involves practically, a general reorganization of the entire service.

As regards the Line, it may be considered as needing but slight changes. The number of Lieutenants should ultimately be increased by one hundred. The title Master should be changed to Sub-Lieutenant, and the number ultimately increased by one hundred. The additional two hundred officers would be necessary to perform the duties of the Engineer, Pay, and Marine Corps, as noted hereafter.

As regards the Engineer Corps, we may well learn a lesson from the French Service. The Engineers should be the *corps d'elite*. The scientific men of the service should there find their appropriate place. They should be, also, the Constructors, uniting in their Corps the offices of designing and construction of vessels, as well as of the machinery to propel them. The number of the various grades should be as follows; One (1) Rear-Admiral, Engineer-in-Chief. Two (2) Commodores, General Inspectors, for duty under the Bureau in the Departments of Engineering and Construction respectively; twelve (12) Captains, to be distributed at the various yards as Constructors, and held for genal duty as supervising Engineers of work outside the Navy Yards; twelve (12) Commanders, for duty as Chief Engineers at the Navy Yards: neither of these two grades should be required to go to sea, except that the Commanders should be required to make one three years cruise while in that grade, prior to promotion; twenty-five (25) Lieutenant-Commanders, for duty at sea as Chief Engineers of vessels, and at Navy Yards as assistants to the Chief Engineers and Constructors. These should constitute the *permanent* portion of the Corps. The *detailed* portion should be Line officers who had specially qualified for it in the post graduate courses mentioned hereafter. On board vessels of the first and second rates there should be a Chief Engineer in charge of the machinery, with one detailed officer to assist him. On board third and fourth rates the Engineer's Department should be in charge of detailed officers. The actual manipulation of the engines should be performed (as it is even now when we have such a large number of Engineer officers) by machinists. Men possessing the requisite qualifications can easily be secured to fill these places, especially if they are made permanent, as they should be. Not only this, but

machinists should be made Warrant officers *of the Line* precisely as Boatswains and Gunners now are. By throwing sufficient safeguards around the issuing of a warrant we would be sure to get proper men. They should first serve a three years *enlistment* as machinists; after which, upon bringing proper testimonials from the officers under whom they served, and passing an examination, they should be *appointed* Machinists. They should receive their warrants dating back to the time of appointment, after a further probation of one year, with favorable reports from their officers. That such a Corps of Machinists is possible we learn from the French Navy, where a similar system succeeds admirably. Vacancies in the Lieutenant-Commander's list should be filled by competitive examination from among the Lieutenants and Sub-Lieutenants who had served at least two details *at sea*. The details should be confined to a period not exceeding five years, the time on shore being spent at Navy Yards and in the Bureau preparatory to going to sea. No officers should be detailed for this duty in excess of the number actually required to fill the places mentioned. It would be a wise plan to pay all the permanent officers a salary higher than that paid to other Corps, as an additional inducement to the best men to enter this important branch of the service. All of the detailed officers of the Engineer Corps should receive an increase of ten (10) per centum on their pay while serving in the detail.

The organization of the Pay Department should be as follows; One (1) Commodore; two (2) Captains; seven (7) Commanders, and fifteen (15) Lieutenant-Commanders, for duty at the various Navy Yards, and as Purchasing and Disbursing officers at the various shore stations; these should comprise all the *permanent* members of the Pay Corps; the duty of Pay officers at sea should be performed by Lieutenants detailed for that purpose, for a single cruise; these officers should not be detailed for this duty for two successive cruises, but, at the expiration of their three years detail, should return to their duty in the Line. That this scheme could be carried out readily, seems to me most clear; and that it is by no means a novel plan, I quote as follows from the "Army and Navy Gazette" of September 7th, 1878, viz. "The navigating branch is being gradually absorbed, and owing to the progress of naval science very much for the good of the service; why should not the Paymaster's Line be allowed to fade away honorably and gradually? The mystery of ships' books and accounts cannot be very appalling to those who have passed Greenwich, and the post of Paymaster might easily be filled by an executive officer who,

for the sake of increase of pay, may be content to give up the prospect of rising to the highest rank in the profession. . . . . . What really is wanted is that there should be a number of officers who have specially qualified for Staff appointments by a course of study similar to that gone through by military officers at the Staff College; from whom should be selected the personal staff of flag officers . . . . ; also to stop the entering of a separate class for office duties, and by degrees replace them from the executive branch. By doing this a class would be abolished and many of the disputes and grievances which arise on board ship rendered things of the past; and so many more officers available who would be competent to take charge of ship's boats or men in an emergency."

A similar plan has been proposed in the French Navy, and is, I understand, carried out in the Russian Service.

It is very certain that "the mystery of the ships' books and accounts cannot be very appalling" to a graduate of the Naval Academy; and by detailing the Paymaster from the Line we should gain the advantage, as noted above, of having an additional combatant officer who would be useful in action, or who could stand a watch or do other like duty in case of emergency. The vacancies in the permanent portion of the Corps should be filled by competition from among the Lieutenants who had served two or more details as Paymaster at sea.

The Marine Corps should remain as it now is in the higher grades, except that the grade of Brigadier-General should be revived, and the number in the grade of Majors should be increased to fifteen (15), sufficient for duty at the Navy Yards and shore stations, and to command the guards of flag ships: the duty of the subordinate grades of Marine officers at shore stations should be performed by Lieutenants and Sub-Lieutenants, detailed for that purpose for a period not exceeding three years: one of the watch officers of a vessel should be the commanding officer of the marine division, and he shonld have served on the shore detail before being sent to sea for that duty. Vacancies in the permanent part of the Corps should be filled by competition from the Lieutenants who had served two or more details as above noted. To the permanent officers of the various Staff Corps should be applied the provision of law, as in the Army, that they should exercise no military command.

It may be objected to this scheme of detailing officers that it is not only novel but impracticable. It is perhaps novel as regards the Navy, but it is not so as regards the sister service. In the armies of near-

ly all the principal foreign countries the Line and Staff officers are interchangeable, the Staff being wholly made up (in the junior grades) of details from the Line for a fixed term of years. Brevet Major-General Upton in his report on "The Armies of Asia and Europe," lays the greatest stress upon this principle; and in his scheme for the reorganization of our own Army provides for the system of staff-detail in its fullest application. I am firmly convinced that it is the only way in which we can ever harmonize the differences which exist in our service between the Staff and the Line, and which can utilize to the fullest extent the fighting power of the *personnel*, as well as offer suitable inducements to the scientific minds to enter the Corps where they will be of the best service to the country.*

But this scheme of detailing officers from the Line to perform the duties of Engineer officers would not succeed unless there be additional means provided to prepare for that duty. The graduates of the Naval Academy are certainly now able to do the duty of Subaltern Marine officers, and it would require but a very slight amount of instruction to enable them to fulfill the duties of Paymaster. But it is obviously not so with the Line officer who is to be detailed for the Engineer Corps. He must have placed at his disposal the means of improving himself in his profession. Advantage should be taken of the education acquired at Annapolis to establish a post-graduate course, or rather several such courses, some of which should be obligatory, others optional. All officers upon reaching the grade of Ensign, should immediately be ordered to the Torpedo School, to undergo the course of instruction there, and they should be *required* to pass a satisfactory examination at its conclusion. Another obligatory course should be in steam, both practical and theoretical. The Torpedo Station should have its facilities so enlarged that *both* of these courses could be pursued there. This could be very readily done with comparatively slight expense.

The optional studies should be in Ordnance and Surveying, with a higher course in Steam, and a thorough course in Naval Architecture. The course in Ordnance should be an amplification of that which now exists in the Washington Navy Yard, and this could readily be effected with no additional expenditure of money.

A course in Surveying is now furnished to officers who enter the Coast Survey, but it might readily be made more extensive by giving

* This principle is also recognized in the Burnside Army Bill now (December. 1878,) before Congress.

to these officers opportunities to become familiar with the theory and practice of the determination of positions by the use of field instruments.

The *higher* course in Steam should be pursued at Annapolis, where also, should be taught Naval Architecture. Only those officers who had passed with credit *both* the obligatory courses should be eligible to pursue this advanced course. Instruction should be given by lectures and text-books; examinations should be frequent and searching, and the failure to pass should cause the instant detachment of an officer from this duty ; for this course are wanted the *very best* men that can be procured.

I have made no attempt to elaborate the details of these various post-graduate courses, as I do not deem myself competent to do so; but the specialists, whom we already possess in the service, would find no difficulty in preparing suitable programmes.

All that has been said heretofore applies to the future ; the question naturally arises what is to be done with the officers now on hand ? So far as the Line officers are concerned, all these courses should be at once thrown open to them, and all of this might readily be done without any additional legislation, save an appropriation to enlarge the facilities of the Torpedo School, as indicated above.

With regard to the Pay and Marine Corps, appointments should cease at once, and the system of details be begun, as the wants of the service required. Both of these matters could be easily settled. With regard to the Engineers we *might* conform somewhat to the plan pursued in the English Navy, in doing away with the Navigating Officers. So far as possible the lower grade should be at once absorbed in the Line. Any Passed Assistant Engineer (with the relative rank of Lieutenant) now on the list, who desired, should have the option of standing the examination now passed by a Master for Lieutenant, and if successful should be commissioned as Lieutenant from the date of his examination, and he would, of course, be eligible for detail in the Engineer Corps. At the expiration of two years this option should cease, and the vacancies then remaining in the Lieutenants' list be filled by promotion from Sub-Lieutenants. Those Passed Assistant Engineers, who failed or declined the option, should not be promoted to Lieutenant-Commanders in the Engineer Corps, *unless successful in the competitive examination* above-mentioned (which should, of course include Naval Architecture,) but should remain upon the list in their present positions. Any Passed Assistant or Assistant Engineer now on

the list with the relative rank of Master, should have the same option to become a Master; and any Assistant Engineer now on the list with the relative rank of Ensign, should have the same to become an Ensign; all those declining or failing should be promoted to Passed Assistants, under the same condition as above prescribed. Vacancies on the Sub-Lieutenants' list at the expiration of two years should be filled from the grade of Ensign by promotion. Cadet-Engineers and Cadet-Midshipmen, graduates of the Naval Academy, should be *required* to pass exactly the same examination, facilities being given them for study at the expiration of their two years cruise after graduation; and they should be promoted as if they had all originally belonged to the same class, ranking according to merit. For the Cadets in the school the course should be changed to *five* years at once, and no more appointments made under the old system. In two years, then, this entire plan for the reorganization would be well under headway, and in five years the good effect would be manifested. No more appointments of Assistant Naval Constructors should be made, and no promotions to the grade of Naval Constructor. Competent Chief Engineers should be allowed to enter upon the duties of Constructors, and inducements offered to the present Constructors to retire.

Such, in brief, is the scheme which, when properly elaborated as to its details, by hands more competent than mine, will in my opinion, bring harmony to the service and add more to its efficiency than any other system that could be pursued.

## II.—Men.

While it is necessary that we should do all in our power to raise the standard of the officers of the Navy, it is no less important that we should turn our attention to the men.

The system, or rather the want of system, of former days is confessedly a failure in securing for the service the right character of material for the modern man-of-war's-man. The want of to-day is energetic, self-reliant young men trained to their profession from an early age, who shall look upon the service as their home.

It is evident that a sailor cannot be made upon dry land. He must be afloat—must identify himself with his ship and become part and parcel of her. And as the duties of the Naval officer differ from those of the officers of the merchant marine, so do the duties of the Naval sailor differ from those of the sailor who serves in a merchant vessel. It, therefore, needs a special education to evolve the man-of-war's-man.

The apprentice system, which is now under full headway, is a most happy means to this end, and upon all sides are heard the encomiums of those Commanding officers who have been lucky enough to have any of the apprentices on board of their vessels.

That the boys should be selected with very great care is at once evident. The life is by no means an easy one, and it requires a most excellent physique to answer all the demands made in active service. Two things should be at once impressed upon the boy; that he should keep himself clean and that he should learn to make his own clothing. Swimming should be taught also, and every opportunity that offers itself should be availed of to give the boys practice. These are cardinal maxims and hardly seem worth repeating. Indeed, it is a work of supererogation to attempt to detail the course to be pursued with apprentices, for the general sentiment of the service is so much in favor of the system, that it is merely a question of slight details as to how it is best carried out. A special care is, of course, necessary, that all the boys should have thorough instruction in seamanship, gunnery, and small arms; and I am sure that no one who has ever seen the "*Saratoga*" can say that the system there pursued does not turn out excellent young men—men upon whom, as years go on, the country can rely as efficient guardians of its honor.

One thing, however, should be strictly kept in view, and that is, we are educating these boys to be enlisted men, not officers; and no false ideas of future promotion should be brought before them as an inducement to enter the service. The failure of a previous attempt at an apprentice system was largely due to the fact that such ideas were prevalent. But it is not with the sailors proper that there is now so much reform needed as with the other classes of men we find on board ship. I refer to the men composing the Engineer force, the servants, and the general assembly known in nautical parlance as *idlers*. No man should be allowed to form part of the ship's company who is not an efficient addition to her fighting strength. The firemen and coal-heavers should be trained for that duty, and, in addition thereto should know how to pull an oar, to work the guns of the battery, and to be efficient small-arm men. The question as to the best method to be pursued in their training is one of great importance. I regard it as quite necessary that these men should be as good seamen as the apprentice ships can turn out. Having this as a foundation, any man of sufficiently good physique to stand the effects of the heat can (with that power of adapting himself to circumstances which is eminently characteristic of

the seaman) readily acquire sufficient facility in the manipulation of fire-tools to perform the work of the fire-room; for this is not the sort of labor that can properly be called *skilled.* Such is, however, the characteristic of that kind of labor we look for in the Machinist. Firemen who showed ability, or men otherwise specially selected, should be given opportunities in the Navy Yard workshops, under the supervision of the Engineer officers, to learn thoroughly the use of tools and the general mechanism of the steam-engine, in such a manner as to fit them for the position of Machinist. With a corps of such Warrant officers as I have referred to in the first part of this essay, and with the men under training at the Navy Yards, a large portion of the repairs to machinery might be made, at a great saving of cost to the Government. With men who had passed through the course of training on board the apprentice ship, in the engine and fire-rooms, we should have a reserve force on board ship which could be called on to render efficient service in times of emergency. And we should still further consolidate and amalgamate the men, as I propose to do with the officers, making of the ship's company a homogeneous, instead of a heterogeneous, organization.

One great evil to which we are subjected on shipboard is the multiplicity of servants. These men are enlisted for duty in the powder division, and are assigned as officers' servants. Of course there must be some one to cook for both officers and men. The ship's cook is more frequently a thorough seaman (one who has been a petty officer) than otherwise; an arrangement could easily be made by which selected men could be trained (while on board the receiving ships) for this special duty, and this would prove of great advantage. As to the officers' cooks, I suppose that they must still be picked up as occasion offers, but there should not be so many as now. I can see no reason why two cooks should not be sufficient for all the officers' messes, provided enough pay is given them to secure the right sort of men. These, together with a steward and assistant, (whose pay should also be ample), would be sufficient to provide for the wants of all the officers, except in the case of vessels having a flag-officer on board.

The system of numerous messes could be greatly modified also. The Commanding officer could mess with the other commissioned officers, in the same manner as is done in the Coast Survey, while still living in the cabin; also, the Steerage officers could *mess* in the ward-room while living in their own quarters. The Warrant officers (including the Machinists) would form a separate mess. Now, if we cut off the present

source of supply of men who are for duty in the powder division, we must seek some other fountain whence to draw them. Such I find in the Marine Corps. The additional men required in that corps for this duty would be but few in number, and their cost to the Government would be no more than that of those whom they displaced, while their presence would add greatly to the efficiency of the vessel to which they were attached. This is substantially the system pursued in the English service, and which I am led to believe works excellently. If we could but get rid of the useless servants whom we now have, (useless to the ship herself, I mean,) and replace them with selected men from the Marines, it would be a great step in advance, and would enhance the efficiency of the service as a whole, by giving us men who had received military training in place of those undisciplined and untrained creatures who are a constant source of vexation and trouble during an entire cruise.

To the Marine Corps, also, we should look for our supply of the special police force of a ship; Masters-at-Arms should be selected from Sergeants of Marines; and as competent men are always to be found both among them and among the bluejackets also, we could draw our supply of writers and storekeepers from those who have had such training as to render them effective auxiliaries, instead of positive drawbacks, to the fighting force upon which a vessel could depend in emergencies.

Such are the systems of training for both officers and men which my observation has led me to believe will tend to improve the status of the personnel of the service and render it (under the new and ever-varying conditions of modern Naval warfare) as competent to enter the lists of battle, as it has shown itself to be in the contests in which the country has been involved during the century of its existence. But whatever may be in store for us in the future, we should always bear in mind this truth: "he who does not progress, goes backward."

# THE RECORD

OF THE

# UNITED STATES NAVAL INSTITUTE.

## NAVAL EDUCATION.

By Lieutenant-Commander C. F. Goodrich, U. S. N.

"*Esse quam Videri.*"

The American people, as a natural deduction from their keen love of liberty, have ever cherished an equally keen antipathy to a large standing army and navy. It is therefore unwise to hope for the stimulus of liberal budgets and a favorable public opinion on the one hand, and, on the other, that sense of personal devotion to a sovereign which has called forth, in other lands, such marvels of courage and self-denial. That the pure and lofty patriotism based upon a broad and deep realization of the duty owed to their country has incited our predecessors, and many yet with us, to equally glorious achievements and painful self-devotion cannot be denied. Nor is the Naval Officer disposed to yield to any fellow citizen one jot or tittle in love of country, in readiness to risk all for her, or in earnest desire for her material and moral prosperity.

The very problem set us to be solved to night derives its weight from the earnest wish, on the part of her Naval Officers, to determine, as far as possible, how the opportunities afforded can best be improved, that officers and men may be worthy representatives and useful servants at all times and, in the hour of need, staunch, able and vigorous defenders of their country.

In a few words, we are to ascertain what modifications, if any, are necessary to make our system of education result in a *personnel* of maximum elasticity and efficiency with the resources at our disposal.

Naval education, when viewed in this light, will be found to assume new dignity as the well advised means towards a noble and laudable end.

A vivid notion of this end and an honest appreciation of its importance will greatly aid us in clearing away the fogs of prejudice and tradition that hang over the debatable land across which our path must lead, and will, it is to be hoped, stimulate in us a kindly sentiment of mutual consideration, making us sink all personal feeling and bear with each other in the common cause.

To officers in the Navy are assigned duties so varied that their enumeration alone can barely be hinted at.

The Naval Officer builds ships of wood and of iron, the boilers and engines, the spars and sails that propel them, the guns that arm them. He commands them, cares for them, fights them, repairs them. He watches over the men under him in health, and attends them in sickness. He is entrusted with the most delicate international relations. He protects the merchant marine, quells its mutinies and lends it a helping hand in time of need. He succors the shipwrecked. He maps out the surface and the bottom of the ocean; surveys rivers, harbors, coasts at home and abroad; establishes astronomical positions; records and predicts tides, observes eclipses, transits, and occultations. To him, in time of peace, the people look for routes across tropical isthmuses and to the North Pole; for new continents discovered, fresh outlets for trade. In time of war, his name is the symbol of efficient defence and vigorous attack. To-day he is with his kindred, a modest retiring citizen; tomorrow he is the guest of crowned heads, yet ever proud of his profession and sensible that all honors are but paid through him to the country that gave him birth. Such are some of the tasks set before him, and he is the best servant of the nation who best performs these manifold duties.

Likening the officer to the mind which plans and directs, and the man to the hand that executes, the question takes definite shape: how shall we develop this mind and train this hand that the two may work in unison and to the best advantage in the country's service?

To him who would answer this question three courses are open.

First, accepting the present organization of the Navy, to point out the way in which it can be made to attain its highest development.

Secondly, to sketch a plan of navy organization, and its consequent education, which should be as nearly as possible perfect in all its details.

Thirdly, to modify, add to, and combine existing propositions for reform in the Navy, moulding them into a homogenous mass and then

to construct a scheme of training by which the new plan may be made to yield the best results.

Upon deliberation the latter course has been chosen, for in it is found much now sanctioned by law or stamped with the approval of eminent authority, a practicable mean between what is and what might be. That any well digested plan of naval education should involve a consideration of naval organization is unfortunate, but the two subjects seem to be so mutually dependent that a satisfactory treatment of the one, without trenching upon the other, appears hopeless. Should attention be incidentally drawn to the kindred and equally serious topic, much benefit to both might accrue.

## I. Officers.

The plan for the education of the officer which is offered for your consideration comprises three integral parts:

1st. General schooling of cadets at the Naval Academy;

2nd. A lengthened probation at sea to secure experience in the service and the habit of command;

3rd. The establishment of a Post Graduate Course for the encouraging, fostering, and developing of the specialties of the profession.

It is essential that the position to be assumed under the third of the foregoing heads should be made definite at the outset, for it involves nearly every innovation which will be suggested.

We are all deemed naval officers, no matter what be the corps or the specialty. I am strongly urged to believe that the difference of corps is merely a difference of specialty, that the one may be made to replace the other with benefit, and that the needs of the service, with the exception of surgeons, will be best supplied by officers of broad naval training and experience who have devoted themselves to particular lines of thought and labor from deliberate choice, based on a full knowledge of the wants of the navy and their own mental bias, and who have followed these lines with the earnest zeal and untiring vigor of early manhood.

To this belief, against my preconceived notions and to a certain degree against our traditions, I have found myself gradually but surely impelled. It appears a logical deduction from the premises, the conditions to be fulfilled.

The sea officer can no longer afford to remain in comparative ignorance of the modes of disbursing and accounting of government funds, or of the theory and practice of the motor upon which may depend the

safety of his ship and the issue of battle—nor, on the other hand, can the government afford the luxury of paymasters restricted by capacity to the performance of their own narrow duties (I say it with all respect) and of engineers useless except while steaming.

Given the vast fund of intelligence scattered broadcast over our land from which to draw recruits, the inducement of an honorable calling, a comfortable income and liberal retirement during life, with a pension for the family thereafter, it is not too much to assert that no matter how high we raise our standard of mental and physical ability we shall never lack a superabundant supply of properly qualified young men to fill the navy list with good sea officers able to direct and superintend any of the departments of ship board.

The duties of the paymaster and the marine officer can be performed without difficulty by line officers detailed for the purpose. I may remark parenthetically that, in the case of the former, this has already been done successfully in the Imperial Russian Navy.

That the engineer may be advantageously replaced by the sea officer, who has been trained in the manner to be shortly described, will, it is hoped, become evident.

As to the other points, there can be little difference of opinion ; here however it is necessary to make haste slowly and to be clear beyond the possibility of misunderstanding.

The average line officer justly believes himself competent to take charge of the engines of a ship in the event of emergency, and a knowledge of the elements of steam engineering is essential in his various examinations.

Even if this be too strongly stated, that such ideas should be entertained at all and in their mildest form is significant. It shews, conclusively, that the times have changed, that more is demanded of the officer now than in by-gone days, and that he must needs be familiar with matters pertaining to his calling other than the bare routine of duties. It is also true that the engineer is no longer the engine driver and mechanic, but an officer, like his colleagues, of culture, science and reflection. The engine driving has passed into other hands. With the engineer still rest the responsibility and superintendence of running and repair. The cadet engineer and his training, the assistant and his duties, are a perfectly normal development. They indicate the kind of engineer considered most desirable for the navy by those commissioned to speak with authority on this subject.

A glance at the curriculum of the Naval Academy will however suf-

fice to make evident how readily the studies pursued by the Cadet Midshipmen may be extended to cover, in addition, the special ground now passed over by the Cadet Engineers. This will be the more easily effected when the establishment of the Naval College shall permit the postponing, to a later time, and for those only who are desirous of its benefits, the study of certain higher branches which go to form what may, by analogy, be called the Naval Officer's "Superior Education."

The proposed abolition of the Pay, Engineer and Marine Corps could only be carried into execution in the course of time; the present arrangement of duties continuing until these corps had gradually disappeared—their similar grades in the line being correspondingly increased.

To substitute a homogeneous whole for the present needlessly diversified organization is no light task, but that it must be done appears both clear and peremptory.

To argue that cadets should be appointed to the Naval Academy only upon competitive examination is to waste breath in asserting what every one knows to be true, and what every one also knows political patronage will never permit. It is thought, however, not impossible to combine political patronage and competitive examination.

The Academy graduates at present more cadets than the Navy can provide with vacancies. Within so short a space of time as a year or two, there must result a terrible stagnation in the lower grades, a stagnation which can but grow rapidly worse and more distressing; yet, under the present *regime*, to reach a certain standard is to receive the coveted diploma and a consequent lien for life upon the government. The remedy to this defect may be made incidentally to subserve the purpose in view in these pages.

It is suggested that no change be made in the manner of appointing *candidates* for entrance—that they pass a competitive examination in the elementary branches, and that a number be admitted equal to twice the number of vacancies which occurred during the preceding year in the corps known as line, engineer, pay, and marine. For certain reasons, which will be given later, it is believed that the age of admission should be between 14 and 16 years. It may be remarked that the congressional district whose candidates always failed would in any given number of years have enjoyed the maximum of patronage.

At the end of the second year and practice cruise of these there would be retained a number equal to all the vacancies created during the previous twelvemonth in these same corps. This opportunity should

be seized for selecting, not necessarily the cadets whose only merit lay in scholarship, but those who promised to be most valuable as officers exhibiting manliness, zeal, adaptability to the service, the habit of careful observation and the germ of the faculty of command. To this end a board of officers especially chosen for this delicate yet highly important duty should assign to each cadet a number or multiple based on his officer-like qualities, the maximum not to exceed one-half the total maxima for scholarship. The standings being thus arranged to embrace a consideration of the practical as well as the theoretical part of the naval life, the surplus beyond the requisite number would be discharged and sent to their homes at government expense. The effect upon discipline and studies of thus holding out a near and definite prize to be striven for at the Academy can better be imagined than described.

As to the curriculum, there is little I feel competent to propose which would not naturally result from the new order of things. The two courses pursued would be united, the distinction between line and engineer, as now understood, no longer existing, and all the Cadets receive the present instruction in Steam Enginery, Mechanical Drawing, Practical Work in the Machine Shop &c., for engineers; and in Gunnery, Seamanship and Navigation for the midshipmen. The study of Naval Construction, the Designing and Fabrication of Machinery, Higher Mathematics, the Strength and Resistance of Materials, and Law should be deferred to the Post Graduate course; the time thus saved at the Academy to be occupied, 1st, In such lectures as might be deemed requisite to convey the necessary general notions of these subjects, 2nd, To increased practice in Seamanship and Machine Shop Work, in the Chemical and Physical Laboratories, and in Sketching. Upon the value of this last art, I can not lay too much stress, for I have often and deeply regretted its lack, in my sea experience. Nor can I refrain from expressing the desire that the proper use of the voice, so weighty an assistant on ship board, should be carefully taught by some competent elocutionist. The most able officer may be helpless in time of need through inability to make his orders distinctly heard, even while possessing the requisite lung power.

The matter of the practice cruise, however, is not to be lightly passed over. I find myself obliged to think that the present plan, involving as it does, in spite of the earnest endeavors of vigilant officers, the crowding together of sailors picked up at random and a lot of boys, fresh from home, at their most impressionable age, must be fraught

with danger to their morals, and to the tone of the service of which they will one day be the exponents.

During the term, a small light draft brig or barque for trips into the bay once a week on *any* day when the wind serves, and a small screw steamer for engine-room practice and as a tow boat *in posse* would give ample opportunity for practically enforcing the teachings of the class room. The permanent crews of these vessels should be men of that type not infrequent in the Navy—honest and capable—not lesss respected by their officers than their messmates—men to whom we all would willingly entrust our own sons.

For two summers, a practice cruise divided between the steamer and the sailing ships should be made in Chesapeake Bay with possibly, a stretch northwards.

The last six weeks between the terms should be given to the cadets that they may run home for relaxation. With how much more zest would they return to their books and drills and discipline than now from their dreary summer in Gardner's Bay.

The objection often urged against youngsters fresh from the Academy is that they come on board a ship with only the vaguest possible notions of their own place and duties. A simple remedy suggests itself. During their last summer at the Academy let them serve as midshipmen and engineers on board of some vessel or vessels in the home squadron, where, in the school of actual experience, they will speedily acquire, at a time when its lack can occasion no embarrasment, that peculiar technical knowledge of routine and the assignment of work and duty on ship-board so puzzling to the landsman, so necessary and invaluable to the seaman.

Our cadet now leaves the school with much theoretical and a fair share of practical training and able to take a watch on deck or in the engine room without *mauvaise honte.* He should be sent to a large, full-rigged, full-powered ship and forced to perfect himself in the practice of the profession.

He should be made to describe with sufficient minuteness everything of importance and interest to which his cruise gives him access—to sketch fortifications, engines, boilers, dock-yards, machinery, ships, new or strange rigs and people, and to make accurate plans of the boilers and engines of his own vessel. He should be made to keep, in lieu of that detestable fossil, his copy of the ship's log, a scrap book in which to preserve the current history of his calling as embodied in the technical magazines and journals and the leading newspapers. To his famil-

iarity with the latest improvements in ships, guns and armor I would give great weight at his examination for promotion. I cannot but deprecate a style of examination which assumes nothing for granted, which exacts of the would be commissioned officer little more than a reviewal of his Academic knowledge and, in ignoring the rapid strides of naval science in all its branches fails to demand that every aspirant should keep himself abreast of his profession in its very latest phases.

I have purposely taken my youngster from home at a comparatively early age, for I wished above all to subject him to the traditions and experience of our service at a time when his nature is susceptible; I have tried to return him, more frequently than is now the case, to the atmosphere and influence of his home that its hold upon him should be assured; and I have tried to fill his restless years with the assimilation of sound professional food. But his training is far from ended.

As a junior officer, he increases his responsibilities and experience on shipboard, serving by turns on deck and in charge of the engines, noting all the while the possibilities of the service and encouraged to weigh well the advantages of each special career it opens to him.

When, at about the age of twenty five, in the new order of things, he reaches the grade of lieutenant, the early manhood of the navy, his notions have become clearly defined, his bent decided, and his professional taste established. He is competent as a Watch and Division Officer and competent as an Assistant Engineer. He knows exactly what he is and what the Navy is; he can choose advisedly whether to remain a line officer pure and simple, or, in addition, to qualify himself by labor and study for the efficient performance of duty in one of the allied branches; lastly, he is old enough to appreciate, and young enough to improve, the opportunity for training in the special career selected. This opportunity would be found at the Naval College.

This institution should consist of such theoretical and practical courses as would supply the demand for technically trained talent in the navy. Every officer above the grade of master should be eligible for admission subject to certain conditions. 1st. He should, within twelve months, have completed a full cruise of at least two consecutive years, with a reservation in favor of exceptional cases to be decided by the Secretary of the Navy. 2nd. He must have performed at least five years' sea service in all. 3rd. He must indicate the studies and exercises (at least two in number) he wishes to pursue, or the speciality to adopt. 4th. He must pass satisfactorily an examination so rigid as to prove that his application for entry is in good faith and has been

preceded by honest study and careful observation. The college must not be for the recalling of forgotten learning.

The following courses suggest themselves at once; others would doubtless be found necessary or desirable.

1st. Higher Mathematics.

2nd. Mechanics, Pure and Applied; Strength of Materials.

3d. Physics.

4th. Chemistry and its applications to shipboard.

5th. Law, Constitutional, International, Maritime, Naval.

6th. Astronomy and Surveying, Land and Marine.

7th. Practical working in Metals.

8th. Steam Engineering Theoretical and Practical, Engine Construction.

9th. Theory and Construction of Ordnance.

10th. Naval Architecture, Ship building in Iron and Wood.

These courses may be grouped so as to emphasize their bearing. Thus a lieutenant studying to qualify himself as an ordnance officer would take up Mathematics, Mechanics, Physics, Chemistry, Metal Working and Gun Construction; as an Engineer, the same, substituting Steam Engineering, &c., for Gun Construction; as a Surveyor, or Astronomer, the first two, substituting Astronomy, &c.

It is urged that, when their natures permit, these branches be taught practically—that, for instance, the student in chemistry may learn how to conduct a water analysis both roughly to pass judgment upon its potability and quantitatively to ascertain the nature and amount of its impurities; or, again, to determine the per centage of carbon in a sample of steel submitted for gun making, and in metal working how to use a lathe or planer, to forge and temper tools, to shape, tap and finish.

It may become advisable to send the students from time to time to places where interesting and instructive work in their specialities is in progress. Thus at the New York Navy Yard, the laying down or building of a ship or a marine engine might warrant transferring there, for a season, all the students in Steam Enginery and Naval Construction; or the would be Ordnance Officer might spend a few weeks temporarily attached to the Washington Navy Yard during the fabrication of some typical piece of Ordnance. The Naval College, be it understood, is always subordinate to its instruction.

Rigid examinations should be held when each particular part of a course is completed, and only those students whose proficiency is "great" should be passed. Failure to reach this standard should be

followed by detachment from the College. In each branch, the examiners, the Faculty of the college, should be authorized to grade the proficiency either as "great" or "very great." At the end of the whole elective course, the graduate would be given a diploma showing, on its face, all the branches studied, the proficiency in each, and, when sought, the specialty in which he has qualified.

This diploma will warrant placing after his name, in the Navy Register, initials indicative of the specialty, with an additional distinctive mark when his proficiency has been "very great" in every branch. When employed, in consequence of this diploma, on special duty, he should receive an increase of pay, say ten per centum.

The demand for skilled surveyors, ordnance officers and engineers by the navy in general, and for exceptionally capable men as instructors at the Naval Academy is very large. The establishment of the Naval College, with its supply of this much needed *personnel,* will be hailed with joy by every one who has the interest of the service at heart.

The location of this college presents many difficulties. There are required, a library of reference, working laboratories, an observatory and a machine shop close at hand; with gun shops and dockyards not far distant; competent instructors, suitable lecture rooms and either government quarters or ample boarding accommodations. Undoubtedly Annapolis with the Naval Academy facilities, the proximity of the Experimental Battery and the almost vacant Naval Hospital (which could be utilized as quarters) offers a maximum of material advantages. The disadvantages both moral and material, are obvious and grave, but I fear that, in the beginning, at least, they must be accepted. Until the practical working of the scheme be ascertained it would be folly to spend money in duplicating buildings and apparatus. If the Naval College should realize the anticipations of its advocates and satisfactorily supply a pressing want, its settlement elsewhere, in a more favorable spot, might eventually be effected.

And here let me say, that a far greater percentage of officers than is suspected have long wished for an authorized post-graduate course of study in the higher branches of their profession. Many, who would not care to undertake the labor of gaining a specialty, would gladly follow two or three branches in the intervals of sea service, either from love of study or professional pride; and not a few would find, in the maturer pursuit of learning, a salve for the bitterly repented neglect of early days. It is, I think, not indiscreet to say that a large number of officers have, at various times, accepted duty at the Naval Academy

solely as affording an opportunity to refresh and extend their technical or scientific knowledge. From among these, as well as the more ambitious, the applicants for admission to the Naval College will be drawn. That the Navy may no longer be upbraided for misuse of its unparalled opportunities of exploration and research in distant lands, I urge that the Department, at its discretion, permit a limited number of officers, say ten in all, and under the conditions prescribed for admission to the Naval College, to attend certain of our leading universities for instruction in Natural Science, the diploma or degree received to be indicated in the Navy Register.

Should the suggested simplification of Naval organization prove "a barren ideality," the need of a naval college would none the less exist. It is as urgently called for to-day as was the Naval Academy in years gone by. In spite of what may be said to the contrary, the Naval Academy does not fulfil every requirement of schooling. It can not. Its course is a matter of necessity, not of option, and its graduates rejoice, with reason, when it is completed. There must gradually unfold itself in the mind of every young officer a preference for some particular line of duty over the others. This preference can but increase—it is the germ of his greatest usefulness—the expression of his truest force. The navy is suffering, at the present moment, because this bent has been, I had almost said, systematically discouraged. We know, ourselves, the shortcomings of our education and we plead for the chance of bettering it.

The "Applications of Chemistry to Ship board" include among a host of other interesting and weighty matters, with which the *matériel* is chiefly concerned, the philosophy of protecting sailors against damp and foul air, the detection of these foes to health, the safeguards to adopt in malarial districts etc., in short, the Elements of Nautical Hygiene: also, the testing of water for drinking, the *rationale* of food preparation and cooking, with practical instruction in the simpler methods available on ship board. The devil certainly sends the navy its cooks. I can only wonder that their long and unchecked career has been attended with such comparatively little mortality, for they make Jack's grub as indigestible as possible. The ration issued is good in quality, liberal in quantity and of sufficient variety. In the hands of only moderately trained persons it might be made to yield excellent results. I certainly think that Jack may, with justice, look to his officers for relief in this respect.

This branch is of great importance from a naval point of view, in-

volving, as it does, the maintenance of a minimum of morbidity and a maximum efficiency of the ship, for a sickly ship is but half a man-of-war. Every lieutenant should undergo instruction in it, at some convenient time before promotion.

In like manner, the course in Law should be followed by every lieutenant commander to prepare him for decision and action in the many cases of international and maritime law which his service will embrace. This chair at the Naval College would demand a lawyer pre-eminently distinguished for his talents and experience. Its emoluments should be commensurate with its dignity and importance. It may be remarked that its holder, through the proximity (in any event) of the College to Washington, would be enabled to retain his practice in the Supreme Court of the United States.

The lieutenants, who have properly qualified at the College, will be sent on board ship to occupy the place held by the Chief Engineers of the present day, and, in addition, to drill, exercise and care for the men in the Engine Division. Should these officers be more numerous than is necessary, (a most desirable state of affairs, as affording an ever ready reserve,) they will, of course perform their regular duty as lieutenants. In neither case do they lose seniority, and they will be subject, at all times, to any duty of which they are capable. It is believed that they will be at least as competent as the engineers now entering the navy. They will, however, be more valuable to the service at large through their wider sphere and capacities, and their ability, at any instant, in time of need, to stand a watch, fight a gun or command an expedition. It is from this class of officers that I propose recruiting the Corps of Naval Constructors.

Our navy is too small to permit mistakes. Our appropriations are so scanty that we cannot afford costly experiments. Every dollar must be made to bring its full value to the country, and the adjustment of energy to result must be free from blunder. Every frame erected, every bolt driven, every plate riveted, every detail of arrangement must follow as a natural sequence from the care and thought expended upon the plans. No excuse can be found for faulty construction of hull or engines, for a misplaced gun-port, lack of suitable ventilating scuttles, poor lines, bad sea-going qualities, indifferent speed. The nation has a right to expect nothing but success where new schemes are not definitely warranted. Yet, I am credibly informed that the *Trenton* costs as much as the *Sultan*, that the *Tennessee* cost more than the *Alexandra*. It is said that a naval constructor of high standing once

needlessly raised the outboard delivery of one of our largest frigates some two feet, to the water line, because "the pumps could not work against the outside pressure." Many of us have experienced the horrible effects of ventilators emptying the foul gases of the bilge into our rooms and under our very noses. Instances of like criminal ignorance of the barest elements of mechanics arise *ad nauseam* in the mind of every officer who has made even one cruise at sea. When it is remembered that, practically, the only qualifications for this corps, beyond the necessary political influence, are that the age must be between twenty-four and thirty and the applicant a shipwright, the only wonder is that we should have been fortunate enough to secure the honorable few who have been everything good which the corps has contained and who have given us ships of which we may still speak with some degree of pride. But, I submit that these able men should not have been singular; that the money at stake, and the paramount importance of their duty combine to exact, in all, the brightest talent, the deepest study, and the widest experience possible. Instead of being mere shipwrights who have never even necessarily seen blue water, these officers should possess the keenest intellect in the whole navy, should be familiar with ship life and its needs, the behavior of a vessel in a sea-way, under every condition, the strains and stresses to which she is subjected, with the designing, constructing and actual working of spars and sails, engines and boilers, with Naval Architecture and Ship Building in all their phases: in a word, he ought to know everything about a ship both theoretically and practically. Such men are hard to find, naturally; but it is hoped that our Naval College will produce them. The inducement I would hold out to officers to strive for admission to this corps, at once Naval Constructors and Designing Engineers (for it is folly to divide responsibility here) would be the greatest the service affords, high rank, good pay and ordinarily exemption from duty afloat. I am fully persuaded that we should buy their services cheaply at this, or indeed, at almost any price.

Upon reaching the grade of lieutenant-commander, those who had qualified and had served as Engineers would return to the Naval College for the course in Naval Architecture, Ship Building, &c. The instruction in this course should be in the hands of the ablest expert obtainable and no pains or expense should be spared to perfect it. Upon its completion the existing vacancies in the Corps of Naval Constructors would be filled by competitive examination—the successful applicant receiving immediately the rank and pay of Commander. These

officers should not be sent into service on board ship, except at their own request or in case of emergency, but they would continue to be naval officers.

I may be allowed to express the belief that their *esprit de corps* would prove a strong defence against the peculiar temptations to which they would be subjected. Their duty would be the designing and building of ships and engines in all their details, spars, boats, equipments, &c. I venture to predict for them a measure of success beyond our most sanguine expectations.

The foregoing system of naval education, coupled with the changes suggested in the organization of the navy, would result in,

1st. Supplying our men-of-war with but two classes of officers, combatant and medical.

2d. Putting an end to the present needless and costly differentiation of duty.

3d. The developing, by a species of Natural Selection, of trained specialists in every branch.

4th. A Corps of Naval Constructors and Designing Engineers of wide experience and pre-eminent ability.

5th. Incidentally holding out to the ambitious a distinction and a reward for marked professional zeal and attainments.

With an unchanged naval organization, the advantages claimed for this scheme are,

1st. A higher grade of mental capacity on the part of students at the Naval Academy.

2d. The stimulus of a definite position to be secured to the cadet only through attention, study and officer-like qualities.

3d. More frequent leaves with their unquestionable benefits.

4th. Better practical instruction in that prime essential of the service—seamanship.

5th. Sounder training in that other factor, steam engineering.

6th. The postponement of the higher or more abstruse branches to a later date, when their value will be better appreciated.

7th. A grading of the standing of cadets more in harmony with the actualities of the service.

8th. Better fitting of cadets for the performance of their duty on board ship.

9th. Systematic cultivation of the observation, and careful schooling in the practice of the profession.

10th. A rewarding of the zealous, upon obtaining their commissions

for familiarity with the latest advancements in Naval Science and Art.

11th. Official encouragement of the study of Natural Science at some of our Universities, during the intervals of sea service.

12th. An incentive and an opportunity to study, under competent instructors, any speciality of the profession before assuming it definitely as a life's task.

13th. Supplying each of the various departments of the navy with trained men for its technical and scientific work.

## II. MEN.

The necessity is urgent that every man on board ship, with few if any exceptions, should possess a knowledge of the rudiments of his general calling; that, first of all, he should be a sailor, able to lend intelligent assistance in time of need in saving a spar or a ship, to handle an oar in a boat lowered to rescue a drowning comrade, to load a rifle rapidly and fire it with accuracy, to serve a gun whose crew is crippled, at a time when one more efficient piece may turn defeat into victory. It is not however meant, that all should be seamen in the full sense of the word; for a true seaman is expected to be able to knot a parted shroud, to pass a weather ear-ring, to mend a sail, patch a boat, handle tools, in short do anything and everything on board ship. But the requirements on the part of the other members of the ship's company are not onerous (any apprentice at the end of his term can fulfil them) nor is their subject any the less capable in his special occupation.

A long continued and unsuccessful attempt to secure the proper elments of a crew in the open market of the world's sailors has shown. conclusively that, to get what the service needs, the service must take American boys at an early age and train them after its own pattern.

The faults which have shipwrecked former apprentice systems are, 1st, an almost inevitable tendency to coddle the boys and thereby practically unfit them for the rude life they have chosen; 2d, an equally almost inevitable tendency to give the boys more book learning than is necessary, and, in general, to substitute theory for practice; 3d, holding out inducements of rank and position which but few could possibly attain; 4th, lack of the constant drilling with spars, sails, &c., for which chiefly, the school ships were instituted; and 5th, a not infrequent buncombe administration where the essentials were sacrificed to display.

The present training system is in wiser hands and promises to avoid the errors of the past. It seems odd, to say the least, that there should be no single head nor indeed any one authorized plan in detail for the

governance of all our school ships. What may not be positively harmful, at this writing, might, by a change of officers, result in hopeless confusion. It is suggested that the various branches of this highly important service should be united under one well considered administration. The officer best fitted to direct this administration is too well known to need mention.

The *raison d'être* of the apprentice ships is the teaching of boys to be man-of-war's men—nothing more and nothing less—they are not schools in English Literature or Universal History, nor, indeed, are they schools at all, strictly speaking, but they are *training ships* in the fullest sense of the word, to recruit the navy with American lads of good *physique* and *morale*, brought up in the ways of the service and accustomed to look to it for a home and an occupation all their lives. From this point of view, whatever tends to raise them above their calling, to make them dissatisfied with it or to impair their usefulness, is bad. The system has but one end—there are and can be no side issues.

The conditions of ship life are so strange to the novice as to demand a fairly large proportion of his training. The habit of cleanliness in dress and person is of first importance. I am told, by those experinced in the matter, that this point gives infinite trouble, necessitating constant vigilance and inspection. The average apprentice appears to be wedded to his pristine dirtiness. The making and mending of his own clothes is a next step. This art is, or should be, acquired before the apprentice is drafted into a seagoing ship. Many boys learn the use of the needle within three or four months so as to supply their bags and keep them in excellent order.

Time is too short to waste in a discussion of the book learning the apprentice ought to receive. Every one is agreed upon the three Rs. My own convictions, however, are strong against any instruction whatever beyond the barest elements. I do not say that the apprentice will not be a better man for the possession of greater knowledge but I do say that the navy will, in nine cases out of ten, lose his services. The life before him is clearly and honestly explained before his enlistment, and all false notions and expectations dispelled from his mind. After this to overeducate him into disgust for its routine and discontentment with its rewards is neither right nor politic. It is sacrificing the interest of the navy to a sentiment; or, what is worse, to a lazy device for keeping the boy out of mischief. In any event, we may be sure that this, the least important part of his schooling, will, generally speaking, gain the most attention.

The practical part of his training comprises Routine and Duties, Drills and Exercises, Marlinspike Seamanship, Sail Making, Use of Tools.

Under the first head comes all those means for teaching how things are done on board ship and who does them. The acquisition of this knowledge is mainly a matter of time and experience. It may be hastened by making the youngsters serve by turns in each "part of the ship" and as messengers. Adherence to the usages and traditions of the Navy is evidently of immeasurable importance on board the school ships. In the matter of routine they cannot afford to be experimental.

The second head deals with the efficiency of the ship as a cruiser. Here I plead for conservatism and the old forms in what pertains to spars and sails, and for greater pains and uniformity in the pulling of boats and their handling under canvas. What is prettier than a seamanlike manœuvre in a ship's gig or cutter with a well-trained crew? What is more discouraging to Jack and discreditable to his officers than his having to labor at the oar while a handsome working breeze is blowing profitless? Frequent opportunities should be sought and practice had in landing through surf. Any one who has had to perform this dangerous duty with an ordinary, and therefore unpractised, crew is in a position to appreciate the value of this suggestion. More knowledge on this score will be gained in one actual experience than in years of theoretical study.

The remaining heads comprise the handicrafts with which every sailor should be somewhat familiar. I would have the apprentices divided into three gangs, to work with the Boatswain, Sail Maker and Carpenter respectively, at least four afternoons every week, for three months at a time in each gang.

The Boatswain's gang would learn Marlinspike Seamanship, including, to a certain extent, the fitting of rigging, both hemp and wire. It is suggested that, when feasible, the light rigging of one ship at a time, or various typical parts of her rigging be always fitted on board the school ships. Work upon this rigging would soon be regarded as an honor if permitted only to the most expert members of the gang.

In like manner, the Sailmaker's gang would learn the use of the palm and needle. Suitable work might be supplied to this gang from the nearest navy yards, in the shape of hammocks, light sails, awnings, etc., already cut.

A similar method with the Carpenter's gang is rendered less practicable by the evident impossibility of providing so many boys with the

necessary work and tools. In this case, only a few could be trained at once, but the gang would simply be divided into sections taking turn about.

What is sought is merely that handiness which is generally and rightly assumed to be the sailor's leading characteristic—not the turning out of efficient journeymen. It is believed that better results will be reached by keeping to one trade for some time continuously than by passing constantly from one to the other. Moreover, the interest would not be lost, as the piece of work would be seen to progress from day to day.

When the ship is so placed as to permit, the odd afternoon of the carpenter's gang should be employed in practice in signalling, heaving the lead, and making and repairing flags.

The art of blowing the bugle, or playing on the fife and drum can be so readily imparted to boys that it should be taught at this period. We are all familiar, by experience, with the difficulty of obtaining even indifferent musicians. The few apprentices absolutely incapable of this much music could be profitably employed in other ways, say in learning cobbling.

The singing of the old songs of the navy, now a part of the instruction on board of the *Minnesota,* bears its own commendation.

In the British Navy, lively youngsters are occasionally given a whistle and detailed as "call boys." This plan for training boatswain mates in one portion of their duty appears worthy of consideration and trial, both on board the school ships and in the service at large.

Play is as essential to a boy's well being as his daily bread, and good results cannot be expected from any system in which it does not find both place and opportunity. While tied up to the dock, in winter, all hands should be turned out to grass (or its substitute,) several times a day, in good weather. All open-air games should be encouraged and the necessary apparatus purchased by the boys and the slush fund jointly, when it is not practicable to make them. In view of the universal rule of human nature, that things lightly gotten gain light esteem, I would help in this matter, but not take the burden entirely from their shoulders. It may be remarked that the manufacture of balls, bats, etc., would furnish a slight but rather interesting quota of work to the gangs already mentioned. In bad weather, many excellent games can be played between decks.

While cruising during the summer, a proper playground should be secured in every port, and the boys sent to it daily if possible. For

them, this relaxation would be far preferable to a sailor man's liberty with its suggestion of rum shops and debauch. The usual Saturday and Sunday liberty would, of course, not be abridged.

That every apprentice should know how to swim is self evident, notwithstanding the marvellously large proportion of sailors to whom the art is as a sealed book.

It goes without saying that creditable proficiency in schooling and training, a well stocked kit, freedom from debt, and a good conduct record should be required prior to the drafting of the apprentice into a cruising vessel.

Until the expiration of his term, the apprentice should be regarded by his officers as their especial charge, and his acquirements maintained at the original standard. With the excellent start received on board the school ship, it will be largely their fault if the twig fail to grow into a symmetrical tree, the apprentice to develop into a smart, handy seaman.

The demand for artificers in the navy is large and varied. Each ship must have its carpenters, sailmakers, armorers, machinists, etc., to maintain its efficiency as an engine of warfare. Heretofore, we have been compelled to accept a supply of men more or less indifferently competent, and the competency has, not infrequently, been in direct proportion to the mans' bad habits. It is proposed to seek another and a more satisfactory solution of this difficulty by training such of the apprentices as may desire it, in the handicrafts exercised on ship board, utilizing, for this purpose, facilities already at hand. In this manner, we shall secure homogeneous ship's companies of sailors already familiar with man-of-war life and its many phases, and accustomed to look to the navy alone for their reward for long and faithful service.

Indeed, why should we lack good sailmakers when every navy yard has its sail loft which, in addition to its regular functions might be so readily made to assume those of a school, to the profit of the navy generally and, possibly, the lessening of the appropriations? Must we continue to pick up the refuse of dismantled merchant steamers, and the weedings of factory employees, while our work shops are closed to youngsters in the navy who would gladly fit themselves, if permitted, as boiler-makers, copper smiths and machinists? The same query might with equal force, be put in the cases of the other trades practised on board of our vessels. It is hard that the most lucrative and responsible rates should be practically closed to apprentices who, alone, purpose giving their entire lives to the navy.

The following is an outline of the plan suggested.

The written discharge of all apprentices, upon the expiration of their terms, in addition to the conduct shewing, should carry, if he deem it warranted by capacity, the recommendation of his Commanding officer that the bearer be allowed to become a Naval Trade Apprentice. [This title is put forward only for lack of one more suitable]. Upon the re-enlistment of the former apprentice on a Continuous Service Certificate, and in such rate as he may be able to hold, he would apply for permission to qualify in some specific trade plied on board ship. The granting of this application, by the proper authority, would be followed by his admittance for instruction to the particular designated shop in some navy yard. His name would be borne on the books of the Receiving Ship where he would live, subject to the same discipline as others in her crew, but, during working hours, he would be in the shop ashore, learning his trade under the officer in charge of that department, and more particularly, under the foreman of the gang.

The number of these trade apprentices in each shop, would be fixed by the Chief of the Bureau of Equipment and Recruiting, and should, of course, bear some definite relation to the number of holders of the corresponding rates in the service. At the outset it might be necessary to have the proportion of totals so high as one third. It is believed that one fifth or one sixth would be ample ordinarily.

It is not wise to disguise the fact that the introduction of this new element on board the Receiving Ship, demanding, for instance an, earlier breakfast than their shipmates, and unable to take a constant share in the care of the ship, will be attended with certain difficulties; but the value of this or some kindred plan is believed to be so great as to make its practical execution a paramount duty. To this end, it is suggested that, when needed, they spend their Saturday forenoons on board in lending a hand in the general cleaning, that this point, as well as the necessity of proper and decent appearance, their amenability to discipline and inspection etc., be clearly set forth and understood in the beginning. The privilege of liberty would naturally depend upon satisfactory performance in the shop as well as good behaviour on board the receiving ship.

In practice, the would be carpenter's mate, or carpenter and caulker, might qualify specifically as a shipwright, joiner, block maker, spar maker, caulker, boat-builder etc., and a carpenter's gang on board ship, when large enough, should include one man of each class.

In similar schools, the navy would rear its sail makers, coopers, painters etc., and even its musicians.

No apprentice should be rated seaman who had not qualified as a rigger in some navy-yard loft. For this rate, under the new conditions, I urge more consideration and more pay. Seaman should be a term of honor and a distinction to be accompanied by corresponding emoluments.

The Ordnance Departments of the New York and Washington Navy Yards naturally suggest themselves as proper places for the qualifying of zealous and capable youngsters for the duties of quarter gunner and armorer. Here they would be familiarized with the modes of putting up ammunition, the care, preservation and repair of ordnance and small arms.

The recruiting of the Engine Department, in particular, would be effected in much the same general way. The apprentices desirous of such service would, on re-enlisting on Continuous Service Certificate, be subjected to a special and rigorous examination by the Surgeon, to reject all but those peculiarly adapted in physique for duty in the fire room. They would serve one cruise as coal heavers, being instructed at the same time as firemen by the Engineers of the ship. Their proficiency in this respect would be stated on their Continuous Service Certificate. During the second re-enlistment, they would perform the duty of firemen, thus acquiring practical acquaintance with their calling in its lower developments. Upon the third re-enlistment, the authorized number, selected according to capacity and conduct, would be permitted to enter the dock yard work shops to qualify as 1st, boiler maker or coppersmith, 2d, machinist—one half of the enlistment being passed in each shop. After this they would habitually ship as coppersmiths or boiler makers and be rated higher as occasion demanded. With the proposed system well under way a machinist or engineer's yeoman would only be appointed from the rates of boiler maker or coppersmith.

It is suggested that, at the New York Navy Yard, a school be established under competent experts for ship's cooks and bakers. The former might be taught the various methods of utilizing the navy ration. both of salt and fresh provisions, and the latter how to make sweet, wholesome bread. Admittance to this school should be open to all Continuous Service Certificate men upon the recommendations of their previous commanding officer. It is hard to exaggerate the need of this institution. The daily waste of food effected by the present gener-

ation of cooks would almost maintain a second ship's company; and what is saved from the general wreck is often tasteless and valueless. In the last quarter of the nineteenth century it is idle to say that the old methods are alone available.

Such portion of the three year's enlistment as might be found sufficient, would be passed in the work-shop. At the end of this time, the Trade Apprentice should be pronounced qualified or not qualified; the statement, if in the affirmative, to go upon his continuous service certificates over the signature of the officer under whose charge he had been instructed. The remainder of his term should be served out in the home squadron.

Nurses should be trained at the various Naval hospitals, and Apothecaries at the Naval Laboratory.

The stamp of proficiency borne on the continuous service certificate is not to be understood as entitling its holder to a rate. The law trusts such matters to the Commander, but his choice might well be guided and confined to the authorized eligible, except in special cases, for good reasons.

The foregoing is suggested merely as an outline. The innovations involved are so great and the ground to pass over so new, that the details can only be dimly foreseen. It is thought that this, or some similar scheme having the same end in view, would yield good fruit. But of one thing we are all certain, that the country can no longer afford adherence to the old disintegrating system which has filled our navy with all sorts and conditions of men, and made an American man-of-war a veritable floating Babel. Our mercantile marine, now, let us hope, at its lowest ebb, with the rising tide just making, can not absorb its proper share of boys. For the moment they naturally look to the Navy for refuge and honorable employment. But even in the present state of affairs, the Navy will never secure their better class and be true to itself until they shall know that, short of a commission, upon themselves alone will depend their final reward in position, honor and emolument.

# THE RECORD

OF THE

# UNITED STATES NAVAL INSTITUTE.


## NAVAL EDUCATION.


By Commander A. T. Mahan, U. S. Navy.


"*Essayons.*"

In considering the question of Naval Education for officers and men it is necessary to put clearly before us two things—1st, the material upon which we shall have to begin; 2d, what it is that we wish to make out of that material.

### I. Officers.

In the case of officers the material will probably continue to be lads of from fourteen to seventeen years of age. The attainments of those lads at the time they come into the hands of their Naval educators will vary greatly. I am myself in favor of what is called a low standard for admission to the naval course, for two reasons. First, I think there is rough, substantial justice in the view that where Government provides an education out of the money of the whole people, the entrance upon that education should be, as far as possible, open to all parts of the country; as well to youths coming from less favored sections as to those whose homes are within reach of the best educational facilities. It may seem that the same argument would apply to a reduction of the final standard, or that of the whole course; but, independently of the fact that no argument can be pushed to an extreme, I apprehend experience will show that, once admitted, the effect of force of character and perseverance will be generally equal to overcoming the previous disadvantages. Perhaps in the long run the ease with which more educated boys would master the early part of the course, would tend to slacken their own energies and put them yet more on an equality with their less favored rivals.

A second and stronger reason for a low standard is greater facility of moulding. Remember that we have here before us no mere question of a general education, or carrying on to perfection, in a higher institution, the work already well begun in a lower. The Naval educator has, in any event, to begin at the beginning and fashion, for a special and singular purpose, crude material into a highly tempered weapon fitted for a life and actions which, in their ideal, call for the highest qualities of vigor, endurance and intelligence; (I don't say knowledge.) Under such circumstances it is an advantage that the character and mind should have received as little previous bent as may be.

For these reasons I should prefer that the requirements for admission should be confined to such knowledge as is not easily acquired after childhood, or, if so acquired, requires a very disproportionate time. Reading; writing a good hand; spelling; facility in the operations of arithmetic up to and through decimal fractions; such will indicate, if not the whole, at least the level of attainment that I would require of the candidate. For the same reason, i. e. facility of moulding and shaping character, a matter quite as important as mere brain development in the question before us, I would distinctly prefer lowering the maximum age of admission, (now 18 years).

The lad coming thus into the hands of his trainers, it is necessary, as I have said, before considering the course of education, to consider what sort of man you wish him to be when he enters the service; and what possibilities of future development he should be prepared for. This involves the question of what the ideal naval officer of the present day should be; a question that must be dealt with here, to bring out clearly my idea.

I am persuaded that in our theory of education we have failed in this country to recognize that the progress of the mechanical sciences, and the vast change thereby made in naval vessels and their armaments, as well as in other means of warfare, have made necessary the organization of corps of specialists. Recognizing and dazzled by the stupendous nature of the changes made, and the wonderful things accomplished by the labors of science, those who have had the direction of our naval education, or who have exerted influence upon that direction, seem to run away with the idea that every naval officer, having to use these engines of offence or defence which the student or mechanic has put in his hands, should therefore be able to follow out the long train of laborious thought, be familiar with all the practical processes, by which each of these mighty engines has been conceived and pro-

duced. Singularly enough, in the only case in which an education distinctly special has been laid down, that for the present Engineer corps, the same confusion in adapting means to ends prevails; and the country is now laboriously educating to a very considerable point of attainment a number of men whose duties for many years, and till middle life, cannot rise beyond those discharged competently, all over the land, by men wholly uneducated, in the usual sense.

It is necessary, then, to look forward to the end, and consider really what you should require a sea officer of the Navy to be. We have actually gotten in the Navy, by constantly adding here a little, there a little, to a pass in which we think that each military sea officer, or to use the technical term, each line officer, should present in his own person a compendium of mathematics including its highest branches, its applications to numerous recondite physical problems, considerable knowledge of the physical and mechanical sciences, and an intimate acquaintance with the arts of the manufacturer; all in addition to a command of his own profession proper. Failing this, so many say, he must descend from the high position occupied by him and his predecessors for these centuries past and become the simple drudge of others whose minds have received a more rigorous and deeper, though often narrower, culture. Nor is this a mere thought; only the mental impossibility of cramming more study into a four years' course prevents an attempt to carry the theory into effect.

Let me then try to state clearly what qualities, in my opinion, you should especially wish in the line officer of the Navy. I scarcely think I can err in assigning to the foremost place moral power; strength to control self and others; fearlessness in responsibility and in danger; self reliance; promptitude in action; readiness of resource; calmness amid excitement. No amount of mental calibre, far less any mere knowledge, can compensate for a deficiency in moral force in our profession. I wish carefully to guard myself from implying that knowledge does not increase many of these powers, as it increases for example the resources, or enables accurately to measure danger. My point is this: will those habits of the student, the constant, strenuous application, the amount of confinement and closet work involved, tend to make a man more fit or less fit for the storm or the battle? I believe they tend to impede the growth of the class of moral powers needed at sea; to promote caution unduly; to substitute calculation for judgment; to create trust in formulas rather than in one's self. In truth the matter may be shortly stated thus, that a man does best that which he

constantly does; moves more easily and better in scenes to which he is accustomed; and that it is given to few men to be equally at home on the deck and in the closet, in action and in meditation. Yet this is what our Navy seems to aim at.

Next to moral power follows, in my opinion, physical vigor. Few probably will dispute the necessity of the latter, or the effect which it exercises upon the faculties of the soul. It is most impressive to read of the triumph of spirit over matter, as in the case of the typical naval hero Nelson; yet even Nelson had to yield in the body, though his will remained unconquered and good; though lesser men, would have been brought down long before. Although however I fancy I see injury that has been done to bodily health by over study among officers, I do not think it is as dangerous to the physique as to the morale.

I come last to what very many put first, i. e. the intellectual equipment; the acquired knowledge, I mean, as well as the natural ability. I must here save myself from being misunderstood, by saying that I put knowledge last, not because I undervalue that, or would accept less than a very respectable amount of a kind I will mention later, but simply in comparison with bodily and moral power in a naval officer. No one would be supposed to undervalue physical courage because he said a clear head and legal knowledge were of more value to a consulting lawyer.

The knowledge that is necessary to a naval line officer is simply and solely that which enables him to discharge his many duties intelligently and thoroughly. Any information that goes beyond this point is after all simply culture, which, however desirable in itself, must not be confounded with essentials. This is true although the special culture may be of a kind very closely akin to his profession. For instance the manufacture of ordnance, the intricate questions connected with explosives, have a very close connection with the military part of his business. Yet to say that an exhaustive and exact knowledge of the various processes by which the finished gun and the proved powder are furnished to his hand and of the rapid though gradual advance made in each, is *necessary*, is to occupy ground that is not tenable. Similarly on the sailor side of the profession, it may certainly be said that an accomplished seaman should understand enough of the principles which govern naval architecture and determine the qualities of a vessel, to guide him to some conclusions, above the level of a guess, as to the causes of unsatisfactory behavior in any circumstances; but it is going a long way further to claim that he must be prepared to enter into an

elaborate explanation of the method by which those principles are derived and formulated. Yet the statement that the two branches of scientific research and effort named above are, and must continue to be, the work of two classes of specialists, to me a most simple and evident fact, is practically not recognized as yet by our naval educators.

I confess to a feeling of mingled impatience and bitterness when I hear the noble duties and requirements of a naval officer's career ignored, and an attempt made to substitute for them the wholly different aims and faculties of the servant of science. The comparatively small scale on which those duties are now performed, the fancied impossibility of a great war, the pitiful condition of efficiency into which the material of the navy has been allowed to fall, have all helped to blind our eyes to the magnificence of the war seaman's career. At the same time science has been, and still is, achieving her magnificent conquests; and men, as always, in the presence of the achievements of the moment forget the triumphs of the past. No wonder the line officers of the navy are themselves carried away by an amazed humility which falsely dwarfs their own profession. Yet history does not countenance the idea that an untroubled assurance of peace is a guarantee that war will not come; in the little things of the naval profession of our day and country may be even now the preparation for events as great as those in which a naval captain changed the career of Napoleon. Let us then, in estimating the ideal for which we are to train the raw lad placed in our hands, turn our eyes from the things we too often know to be, the wretched character of most of our ships, the aversion to sea duty, the amount of time passed slothfully in port. Let us forget for a moment the mortification and lack of interest which follows from these, and which are common to all military service in time of peace, and let us look at those duties which are involved in keeping the sea in time of war. For those duties our youth must be trained, and any study that tends to unfit for them should be discontinued.

The officers who, whether in command or in subordinate military position, are to handle and fight a modern ship of war, must have a thorough acquaintance with the general construction of vessels, and with the peculiarities, if there be any of the particular ship. Equally they should all know how to handle familiarly the apparatus for controlling and directing her movements, including in these both sails and engines, the latter a point heretofore sadly neglected. It will be their business to find out speedily how the ship will act under various circumstances of wind, weather, trim, speed, &c., so that they may be

able to know what they can expect her to do in any case; indeed it would be well if that familiarity with her movements became so great as to dispense ordinarily with conscious thought or calculation. A similar close knowledge of the armament and all other equipments is necessary.

For this portion of the requisite knowledge, how great an amount of scientific power is required? Naval construction is involved, naval architecture scarcely at all. Some acquaintance with the mechanical powers and the modes of their applications, but scarcely enough to dignify by the name of science. That the knowledge sufficient to run and care for marine steam engines can be acquired by men of very little education is a matter of daily experience; although the naval system of our country has continued to surround a simple enough practical matter, very different from the designing and building of machinery, with a glamour of science and difficulty which does not exist. Some knowledge of electricity will be needed, if the torpedo form a part of the ship's offensive equipment. In all this my contention is not only that science, beyond some simple elementary knowledge of principles which can be applied practically with the resources of the ship, is unnecessary, but also that the attempt to carry it farther involves the loss of time that had better be applied to practical uses; further that the habit of the student in the laboratory, or over formulas, is as a rule an injury to qualities and habits of mind more necessary to a seaman and a military man.

There is, however, one branch of knowledge, intimately connected with the duties of the sea officer, to which I hesitate to apply a limit of strict necessity. I mean the subjects generally embraced by us under the head of Navigation, with its handmaid Surveying. The importance to an officer of familiarity with all the means by which a ship's position may be determined, and course laid with accuracy, such knowledge as in intricate navigation will insure the most perfect adjustment of carefulness and boldness, is apparent at a glance. The problems relating to the deviations of the compass, especially if iron-clads and iron ships are to continue in the navy, make it desirable that the various causes which lead to or modify these errors should be thoroughly understood in theory, and not merely by rule of thumb. The knowledge should be such as to keep an officer wide awake to any chance of new errors creeping in unawares. Again scientific surveying, it seems to me, falls naturally into the province of the officer whose career is to belong primarily to the sea and to the ship, and not to those classes of spec-

ialists with whom, as I shall afterwards indicate, the seafaring part of the naval career is to be of secondary importance. If our Government should ever determine, as it is to be hoped it will, to use its navy in times of peace for the making much needed surveys in distant parts of the world, it is evidently much to be desired that the officers who will have to go in charge of the ships should be fully qualified to do all the work of the survey proper. At this particular place I may say that so much knowledge of botany, mineralogy and kindred topics as would enable a reconnaissance of the natural capabilities of remote countries to accompany the report of a survey, would increase the power of usefulness in a line officer. I do not advocate making them compulsory, but would make provision for imparting, and offer inducements for acquiring, such knowledge after graduation. This agrees fully with the principle which I hope to show underlies my whole argument, viz: that in the corps of line officers, whose business is to handle, navigate, discipline and fight the ships, should be found all the acquirements necessary to discharge the other duties, save only the surgeon's; or if the statement in those terms seem objectionable, let us say that the other corps should so far acquire the specialties of the line as to be able to bear their share in performing the duties.

I have so far written, not thoroughly nor in detail, but in a general manner and sufficiently for the purpose of such an essay as this, upon the three great heads of Seamanship, Gunnery and Navigation under which the qualifications of a naval officer fall: being careful to say distinctly that under the first head I include such a practical knowledge of the steam engine as will enable him to take charge of the engines of the ship, and render unnecessary the maintenance of a special corps of engineer officers for that exceedingly simple office. There is worthier work for a suitable corps of naval engineers.

And having thus discussed them, I again turn and ask; why this mighty cry for science, in the modern limited sense of the term; limited yet further in our use to the mechanical and physical sciences, as an indispensable part of the mental equipment of a war seaman? Granted, as every one must grant, that such science has its necessary place somewhere in naval administration, what is there in it that the seaman cannot handle and fight his ship, I don't merely say without it, but just as well without it as with it. Yet handling and fighting his ship is his business; and if so, in his education no time should be given to any pursuit which does not lead directly up to those two things, if such pursuit be at the expense of occupations which do lead up to them.

Yet just this, under the delusive cry of science, we are more and more doing.

There are yet three other heads under which the mental acquirements of a naval officer fall: the English studies, Naval Tactics and Foreign Languages. Although none of these are dignified by the name of science, few will find fault with the extent to which they are now carried at Annapolis. About Naval Tactics I shall here say nothing. If I be asked, in my own words, how the English studies or the acquirements of Foreign Languages help a man to handle and fight his ship, I will reply that a taste for these two pursuits tends to give breadth of thought and loftiness of spirit; the English directly, the Foreign Languages by opening their literature. The ennobling effect of such pursuits upon the sentiment and intellect of the seaman helps, I think, to develop a generous pride, a devotion to lofty ideals, which cannot fail to have a beneficial effect upon a profession which possesses, and in its past history has illustrated in a high degree, many of the elements of heroism and grandeur. The necessarily materialistic character of mechanical science tends rather to narrowness and low ideals.

I here mention International and Prize Law as necessary to the mental furniture of a line officer, but only lest I may be thought to intentionally omit them. I do not care to urge their importance, as none will be found to question it.

Do I then undervalue science? Do I ignore the great changes it has made in the appliances and system of naval warfare, or deny the necessity to the service of men thoroughly imbued with its spirit and acquainted with its truths? Not at all, I simply say that while the processes, by which the results of sientific research are obtained, are laborious and difficult, the results themselves, for naval purposes, are instruments easy of comprehension and intelligent use; while the practical use of them, under the varied and often exciting conditions of sea and battle service, calls for other and very different qualities and experience than those of the student or the mechanic. Consequently devotion to science and the production of the instruments of warfare, from the ship itself downwards, should be the portion of certain, relatively small, classes of specialists.

Here I must revert again to my assertion of the pre-eminent importance to the sea officer of that which for want of a better word, I call moral force. When his ship is equipped and his knowledge of her powers complete, the most important part of the line officer's work is

yet before him. I might almost say all his real work is before him; that which has been done is only preparation.

The organizing and disciplining of the crew, the management under all circumstances of the great machine which a ship is, call for a very high order of character, whether natural or acquired; capacity for governing men, for dealing with conflicting tempers and interests jarring in a most artificial mode of life; self possession and habit of command in danger, in sudden emergencies, in the tumult and probable horrors of a modern naval action; sound judgment which can take risks calmly, yet risk no more than is absolutely necessary; sagacity to divine the probable movements of an enemy, to provide against future wants, to avoid or compel action as may be wished; moral courage, to be shown in fearlessness of responsibility, in readiness to either act or not act, regardless of censure whether from above or below; quickness of eye and mind, the intuitive perception of danger or advantage, the ready instinct which seizes the proper means in either case: all these are faculties not born in every man, not perfected in any man save by the long training of habit—a fact to which the early history of all naval wars bears witness. Now this training can only be acquired by an active pursuit of the profession, and not in the closet; while on the other hand the achievements of the student and the man of science cannot as a rule be wrought in the cabin of the seaman. The studious and scientific intellect is not that which most readily attaches itself to a naval life, or if forced into it attains eminence therein; and the attempt to combine the two has upon the whole been a failure, except where it has succeeded in reducing both to mediocrity in the individual.

The record of the Naval Academy may be pretty confidently searched to prove that distinguished academical standing conveys no necessary promise of professional excellence; while on the other hand very admirable naval aptitude is shown in many cases by men, intelligent indeed, but not students. The fact is obscured somewhat by the worthlessness, in a professional point of view, of the tail end of many classes; which however only proves the common experience that there are many irremediable blockheads in the world, as well as many men who are fit for no profession, utterly idle and good for nothing. On the other hand a conscientious student and able man can attain respectability in almost any line. I apprehend, however, that the memory of most who know the service will supply enough instances in either direction to substantiate the main statement; and the annals of the service at large bear

the same record of men of patient research, scientific habit of mind and constant study, who have as such rendered invaluable benefit to the navy, but who yet did not command its confidence as sea officers.

Moreover, when the care of instructors and the conscientious pains of the student have turned out a man well equipped to begin a scientfic career, with distinct reference to the navy, what use is made of him? After the maiden cruise, which, if not too long, would be a positive benefit as a relaxation from study, and means of acquiring sympathy with naval habits of thought, and knowledge of naval necessities, the young man, presumed to have a turn for study and science, begins a career of alternate sea service and shore duty which renders connected application to any one pursuit impossible. Take, for instance, one who would make ordnance and its kindred subjects a speciality. For three years he may be in circumstances which enable him to see and learn, and he advances rapidly; then he is caught up and sent to sea, out of the way of every thing. He has neither access to the periodical or other literature which he cannot afford for himself, nor opportunity to see and keep up his acquaintance with the practical processes chronicled by those periodicals. The atmosphere around him virtually precludes study; for while we may deny that it is impossible to study aboard ship, on the general ground that where there's a will there's a way, it is none the less true that few actively pursue study, as distinct from reading, under the conditions of ship and mess life. The temptations to pleasure, the novelty of many scenes, the constant distractions, the close and heavy air of the sleeping apartments, all tend to compel men to social out door life, and to deter from strong mental effort.

I have wished, so far, to make the point that not only does the habit of life of the student unfit for the life of the deck, but also that the life of the ship interferes vitally with the habits of the student. The result is sometimes seen in the eagerness with which students escape, or enter other branches of the profession, when they can. I would provide, at least partially, a place for such in the navy.

There is yet another reason which I think strengthens my argument in favor of corps of specialists. There are physical causes which unfit men for the active life of the sea officer, but which leave their minds as clear as ever. Physical infirmities, the inroads of age, do undoubtedly often impair the efficiency of the seamen, and of the nerve force, while leaving the intellect untouched. This truth is recognized by the retiring schemes of most great military services, which compel officers to leave the active line of the profession at a fixed age—as well as for cause at

any age. Recognize clearly, however, certain classes of men in the service, whose particular capacity lies in brain work or aptitude for the mechanical science, and those men will not need to be retired for causes which do not affect their efficiency; though they may that of the seaman.

Assuming the principle of specialties is granted, I come next to consider how many classes of such specialists I would have in the service.

Premising that all graduates of the Academy should be line officers, there would, under that general head, be three such specialties: Construction, Engineering, and Ordnance officers. I do not feel sure but incline to believe that Construction and Engineering would ultimately come under one head on the Navy Register; the Senior officer of the Corps knowing and using properly the particular capacities of each officer. I shall hereafter in this paper consider the two classes as one, under the name of Engineer officers.

In addition to the above there would be yet another class of officers, requiring different, but less highly intellectual qualities, who would form the Pay Corps of the navy. It has never seemed to me reasonable to assign line officers indiscriminately, and for a cruise only, to duty as paymasters; but on the other hand I have never seen any reason to doubt that one man could perform the duties both of watch officer and paymaster, particularly if spared divisional work. Hence I would select from the graduates of each year such man or men to be assigned to the pay corps as the wants of that body may demand; he, like the others, to retain his position and lineal rank as a line officer, to do duty and have all the consideration and responsibility of a line officer, while at the same time assuming charge of the pay department in his particular ship.

The officers of the Engineer and Ordnance Corps would also retain their position and rank as established by graduation; but it would be understood that sea service was to be with them the exception and not the rule, and that the main occupation of their life should be the study, development, and oversight of the material of the service. After the first cruise, a term of one year of sea service to every five of shore duty would, in my judgment, be sufficient, up to the grade of Lieut.-Commander, after which no rule need be laid down. The amount of sea service indicated would tend to keep them from losing sight of the practical exigencies of a ship, a fault which has often been found with the present naval constructors. Whenever so ordered to

sea they should take the rank and duties to which their lineal rank assigns them, but sea service should cease when the grade of Commander is reached.

The officers of the pay Corps, on the contrary, should go to sea exactly as the line officers who belong to no special corps, up to the age at which he would, by seniority, be executive officer of any ship to which he would be ordered. The two duties of executive and paymaster would be too onerous when joined ; so at this period of his career I would give the pay officer the choice of remaining in the pay corps with the advantage of less sea service, or of casting in his lot with the sea corps, with the advantage of command. During the remainder of this paper I shall speak of those now called line officers and of the pay corps under the one title of the "Sea Corps."

In these details I will seem to depart from my subject; independently however, of the fact that the word education must not be too closely restricted to direct teaching by others, but rather extended to all influences by which the desired results or qualities are educed. I feel myself under the necessity of defending the system I propose by pointing out briefly the ultimate results at which that system aims. As far as I know there is a good deal of novelty in the general scheme, and novelty's charms are, in naval eyes, doubtful.

My aim, then, is this: To recognize and provide for the existing and perfecting of a small body of specialists, but at the same time to provide that every commissioned officer attached to a ship, save the surgeons, should be capable, some more, some less, but each capable of every military and sea duty suitable to his lineal rank. That they should all be charged with the execution of the same, and should all be in one line of rank ; the distinction of corps being internal to that line.

Promotion would go on in that line and not by corps.

Having thus developed my aim and the reasonings which have led me to it, I now proceed to consider the course through which I would carry the successful candidate for admission to a naval career ; I may as well say the candidate for admission to the Naval Academy, as I base the training I advocate upon that pursued there.

The number of cadet midshipmen now allowed in the service is determined by the number of Congressional districts ; one being allowed to each district, and the appointment vesting in its Representative. I have no change to advocate here. The majority will probably owe their appointment to political or personal interest ; but however objectionable this motive, we are not likely to find many members of Con-

gress with the inclination or time to determine the appointment by other reasons than favor. As there have been some, however, who have shown a desire to select the most worthy applicant, I should like to see the navy department, when notifying a representative that a vacancy exists in his district, add some advice to this general effect: That in the opinion of the Navy Department a simple educational test was of no great value in discriminating between applicants; and that good health, wholeness and vigor of body, and, where they could be ascertained, indications of pluck, perseverance, taking the lead in a manly, not a vicious way, among equals in age, were of more worth than intellectual forwardness, as showing the stuff of which a good officer could be made.

Probably the most rigorous sifting by the course I shall propose would yet graduate fully as many as would be needed to fill the yearly vacancies in all the different corps; and it must not be forgotten that a certain number of appointments, technically styled "at large" are allowed to the President. As the system I propose will only permit a limited number to be graduated, it might be just, or at least kind, to faithful officers of the government to increase the number of the Presidential appointees, so as to allow the sons of such officers to compete for the prize of graduation and a commission. Opposed as I am to a high standard of admission, and proposing, as I have above, that every graduate shall possess adequate knowledge to superintend the running, care, and all ordinary repairs of a steam engine, I would of course do away with the cadet engineers of the present system, who are appointed by a competitive examination before the Academic Board. The corps of Engineer Officers which I propose would necessarily possess the power of running an engine, but their proper duties would be of the far higher order which embraces the designing and construction of ships and engines. The Navy needs a first rate, but comparatively very small, body of such men.

The appointees from the districts, who shall pass the required physical and educational tests, would all form one body under the title of "cadets," "naval cadets," or "midshipmen," whichever may be preferred, I shall throughout speak of them as midshipmen. The existing course, being based upon the plan of having cadet midshipmen and cadet engineers from the start, will need considerable modification.

At first the officers and professors will be wholly ignorant of the capacities of the youths. The first years' course therefore must be the same for all, and yet so designed as to oppose no hindrance to following

up immediately either course, as soon as the specialties have been determined.

For the first year, then, I propose the following studies:

1 Mathematics,
2 English,
3 Mechanical Drawing.

This omits the Modern Languages from the present first year's course. I think I shall have the support of the instructors in French in deprecating, as waste of time, teaching that language before the mixed multitude that forms an ordinary fourth class has been sifted. The time gained from the languages should be devoted to Mathematics and English, more particularly to the former, with a view to completing the course earlier in the second, (or third class,*) year than is now the case.

By the middle of the first year it will be clearly seen in most cases how men will stand. The class should then be divided into two sections, and the higher section should not be kept back by the less able men, many of whom, under this system, will not enter the service at all.

The duties of the officers charged with the drills and discipline will, as it does now, lead them to note the bearing and capacities of each man. I would not have these taken into account in the first year, but in the second I shall most distinctly advocate this, as yet unknown, feature in the tests.

Mechanical is preferred to free hand drawing, as the knowledge of it will be essential to those selected for the Engineer and Ordnance corps.

At the end of the year midshipmen who fail to attain a certain standard of merit will be dropped from the Academy, or else turned back into the succeeding class, according to the decision of the Academic Board in the special case.

For the second year the course would embrace the following branches, for all midshipmen.

Mathematics,
English,
Modern Languages,
Drawing,
Steam,
Mechanics.

* It may be well here to explain the peculiar and rather awkward system of naming the classes which obtains at Annapolis. The students in the first year of their course belong to the fourth class, in the final year to the first class.

This omits from the present course Physics and Chemistry as taught in that year. The time thereby gained I would allot first to Drawing, second to Modern Languages, third to Steam.

It is my hope and belief that, without materially diminishing the present Mathematical course, the time gained in the first (fourth class) year, and the superior ability of the upper sections, would permit of finishing the course in time to take up and complete a very simple course of Mechanics. This last should not extend beyond that necessary for an intelligent charge of a sea officer's duty, and will not necessitate a knowledge of mathematics beyond algebra, geometry and trigonometry. If, however, this cannot be done, then Steam must yield to Mechanics and wait for the third year.

Additional time is here allotted to Modern Languages beyond that now given; this will partially compensate the loss in the first year, and being devoted to the better part of the now reduced class, will perhaps in the end go as far as that at present assigned. The same remark applies to drawing, which gains considerably; being carried through the second half of the year.

In this year the drill and executive officers should note and mark the midshipmen, as to bearing and attention to duty. The effect on class standing should as yet be small, for it will not be possible to give to the third class the same scrutiny of individuals as to the upper classes. Marked excellency or defect can however be noted; and a concurrent unfavorable opinion on the part of the drill officers should ensure failure to pass on to the higher classes. Let us not forget that the aim is to make officers, and let us no more see the practical absurdity of a worthless man's passing into the service, merely because he can stand an examination in books. No observer of the Academy is unaware that men of high class standing are too frequently indifferent to their conduct as officers.

At the end of the two years I would put into operation a plan suggested by a distinguished Superintendent of the Academy, which is as follows. The probable number of annual vacancies in the grade of Ensign, for all Corps, due to deaths, retirements, or other causes, should be estimated by some expert in such calculations, and only that number should be allowed to continue the course with a view to entering the navy. Such number would as a rule be the head men of the class, and that class standing would be determined almost entirely by mental proficiency. I would put upon it a check to which I have alluded above, namely, that if the preponderating opinion of the whole body of

executive and drill officers should be adverse to any man's fitness for the service, that opinion should exclude him, and the next man in class standing should have the vacancy. It will be observed that this check is very different from a power given to the executive officers to choose out men, who fail to attain adequate class standing, to take the place of such as have that standing but who, in the opinion of the officers, have less aptitude for the service. I do not think, that in the first two years and among the large number of midshipmen in the lower classes, officers can distinguish with nice precision relative aptitude; the time given to drills and other duties is very small compared to that given to studies, and the check I advocate would be rarely exercised and then in pronounced instances. It would deal also mainly with those cases of general inaptitude, so easy to recognize, so hard to define, and not with special offences, which are sufficiently provided for by the general discipline of the school supervised by the Navy Department.

The word "sad" is scarcely too strong when applied to the sight of the number of youths yearly turned into the service from the Naval Academy so greatly in excess of the demand. Granting, (which cannot be granted), that no large portion of them are undesirable additions to the Navy, it is sad to think of the hopeless future before them; sad to think of merit weighed down by a mass of demerit above; sad to think of the country depending upon a profession which demands above all buoyant energy and hope, but whose prizes under the present system cannot be reached, till all the buoyancy, energy and hope have been sickened out by weary waiting. Some relation between demand and supply would be established by the system advocated; and the country, whose interest in the Navy is commensurate with its interest in the capacity of its officers, should see such a relation fixed.

With the entrance of this chosen body of midshipmen upon their third year the separation between the sea and the other Corps must be made, and the difficulty of determining the course of instruction is greatly increased. The separate courses now laid down for cadet midshipmen and cadet engineers must be combined, and as I do not propose to lengthen the Academic term of four years, the difficulty of this combination is apparent. There are, however, certain considerations which tend to diminish this trouble. The mass of the class, intended for sea service principally, will not need Calculus, nor Mechanics beyond the elementary course of the first two years. The time thus gained, which will be seen by a reference to the present course to be considerable, (10 hours a week) can be given to steam, English and Modern Lan-

guages. I speak of these in their order of importance from my point of view. The greater portion, say six hours, should be given to steam, of which the sea officer is to have a thorough practical knowledge. Two hours additional to the present allowance, will be given to both English and Modern Languages; with the proviso that if further instruction is considered necessary in drawing, and I think it likely, then Modern languages must give up this additional period to Drawing for one or both terms of the year.

So much for the Sea Corps. For the midshipmen intended for the Corps of Engineering and Ordnance the difficulty is greater, but I think not insuperable. Mechanics for them cannot be disregarded ; but it is to be remembered that while they are to have such a knowledge of seamanship as to be *safe* deck officers, yet the sea is not to be their chief aim, nor will they command at sea. Time therefore can be gained from book seamanship, both in this year and the next. The same remark, I think, applies to Astronomy, a subject which will have little place in their future pursuits. The sea officer, who is to be navigator and surveyor, needs, as a good foundation, knowledge of the motions of the heavenly bodies; not so one whose life is to be mainly spent on shore in pursuit of science of a different kind. From Astronomy and Seamanship, then, I think to gain the time for Steam which the Sea Corps gains from Mechanics.

Additional time for English and for Modern Languages, gained by the Sea Corps, would not be so much needed by the Engineer and Ordnance Corps, for two reasons : First, the time for English is assigned to make up for that which I have to take from the first class course of the Sea Corps, but do not propose to take from the other corps in that year. Second, it is to be remembered that the most intellectual men of the class will have been chosen for these corps; and it is probable that in the knowledge of French, save accent, they will be well abreast the rest of their class, under an arrangement of sections according to proficiency.

This same greater capacity leads me to think that the loss of Physics and Chemistry, dropped from the third class year, can be very largely made up to the midshipmen chosen for the Engineer and Ordnance Corps. It must be remembered that you have, in place of a large class of unequal capacity, a very few picked men, probably not over four or five, not tied down to a low average rate of advance, and to whom the teacher can give a degree of personal attention now unattainable. For the Sea Corps I would make no attempt to take up Physics and

Chemistry, but would leave the subjects to be pursued in connection with a post-graduate course, after the first cruise, in the manufacture and handling of torpedoes.

Before tabulating the course for the second class year, it is desirable to say a word upon the study of Modern Languages, which ends with this year. The French language is of importance not only colloquially, but also as giving the key to a large scientific literature. As such it is useful to both the sea and the more scientific Corps. With Spanish the case is different. A knowledge of it is useful, because it is the language of many maritime countries, and particularly of several republics, large and small, in whose welfare it is the policy of our government to manifest a friendly interest; but scientifically it is of small value. I have therefore dropped Modern Languages from the second term of this year for the Scientific Corps, retaining it for the Sea Corps. I do not however specify which language is to be pursued. It is well known that many youths do not now attain a good knowledge of French; such should continue French, and only those sufficiently advanced should take up Spanish at all. Of course they would be allowed extra credit for the course.

For the third (or second class) year then the course proposed would be as follows:

## FIRST TERM.

| Engineer and Ordnance Corps. | | | Sea Corps. | | |
|---|---|---|---|---|---|
| Seamanship | 1 | period* | Seamanship | 2 | periods |
| Ordnance & Gunnery | 1 | " | Ordnance & Gunnery | 1 | " |
| Astronomy | 1 | " | Astronomy | 3 | " |
| Mechanics (Calculus) | 5 | " | Steam | 3 | " |
| Steam | 3 | " | English Studies | 1 & 1 | period per. month. |
| English Studies | 1 | "*per mo.* | Modern Languages | 4 | periods. |
| Modern Languages | 4 | " | | | |

leaving 1 period to be given to Mod. Languages or Drawing as may seem best.

## SECOND TERM.

| | | | | | |
|---|---|---|---|---|---|
| Seamanship | 1 | period | Seamanship | 3 | periods |
| Naval Tactics | 1 | " | Naval Tactics | 1 | " |
| Ordnance | 1 | " | Ordnance, &c., | 1 | " |

* The period is two hours; there are fifteen periods in one week; three in one day.

| | | | |
|---|---|---|---|
| Steam | 4 " | Steam | 4 " |
| Mechanics | 5 " | English Studies | 1 & 1 period per month. |
| Physics | 3 " | Modern Languages | 3 periods per month. |
| English | 1 period per mo. | Drawing | 2 " |

It is probable that to give proper instruction in Seamanship and Astronomy to the Engineer and Ordnance Corps, with the limited time allowed by this programme, a very carefully considered compendium, in the shape of a new text book, would have to be drawn up for each subject. I think there is no impossibility in the way of doing this.

With the beginning of the final year I should adopt a new system with the Sea Corps. The theoretical instruction in Seamanship and Steam should now be followed up by constant practical exercises, through the ships that should be attached to the school. In order to this I would give up the third period, or afternoon of each day to such practical work; to which should be added the drill time, in all three or four hours a day.

To gain this afternoon time, in all ten hours, or "five periods," to use the terminology of the school, I would give up the subjects of Heat and Light in the Department of Physics, Spanish in Modern Languages, and one period each from Seamanship and Steam.

To defend a step which will probably provoke much adverse comment I must say, what we all know to be the case, that no dependence can be placed upon cruising after graduation to supply this necessary practice. The exigencies of the service, the fancies or indifference of individual admirals or captains, keep ships often idle for long periods in ports. Some captains interest themselves in seeing that their young officers acquire practical experience in their profession; others do not. No certain reliance can be placed upon opportunities after graduation.

To obtain these I would unhesitatingly make the sacrifice of study hours and of the branches named for the Sea Corps.

As the lower classes would not take part in these exercises, the necessary force must come from the general service; and nowhere, I believe, would a hundred good seamen and twenty-five or thirty firemen be more fruitfully bestowed than for such purpose at the Naval school.

Nor, though the drill time is to be used for these exercises, does it follow that the first class are to have none of the usual drills. Let us imagine a class of twenty-five destined for the Sea Corps, and a favorable day for exercises of every kind.

1 drills a company of infantry.
2 " batteries of light artillery.
1 " a squadron of boats.
10 go to steamer to run engines.
4 " " to be manœuvred under steam and sail, to take deck and forecastle alternately.
6 to go to sailing sloop where they will take deck or forecastle.

It is not necessary to elaborate, though one is tempted to do so; the combinations of drills that can be made will be innumerable. Those that are to take charge of the three drills first named, in which midshipmen of the lower classes are to be engaged after 4 P. M., need not lose the previous time. They can join any of the latter three exercises and be sent ashore by one of the Academy steam launches, after taking their share, in time for the ordinary drills. Nor is a young mind distressed by thus going from one occupation to another, as older ones sometimes are.

Two things are evident:

1st. Every first classman will thus have abundant opportunity of bearing a principal part many times in every kind of drill and practical exercise.

2nd. The duties of subordinate officers, lieutenants of companies, in charge of single boats, &c., will be devolved on second classmen, who now rarely fill any more important function than high private.

The practical exercises of Saturday will remain for the advantage of the Engineer and Ordnance Midshipmen; it will be remembered that the special practical work of these, viz., the designing, construction and care of material, must come after graduation,

To gain the required time for exercises in the second term, I would omit English studies (Public Law) from the present programme having already provided for it in the second class course.

For the Engineer and Ordnance Corps I would leave the course very nearly as it now stands in the Academy programme. Spanish, for reasons already given, would disappear, and the time be assigned to Gunnery and Ordnance.

The very great amount of time now given to steam should be distributed, according to the Corps to which the midshipman is destined, to Naval Architecture, designing and construction of machinery, or the more advanced study of ordnance problems. For, as these two classes of midshipmen have been before together separated from the mass of

the students, the time has come with the closing year to divide them one from the other.

The tabulated result would be the following weekly programme of studies for the First Class of Midshipmen.

## FIRST TERM.

| Sea Corps. | | Engineer and Ordnance. | |
|---|---|---|---|
| Naval Construction | 2 periods. | Naval Construction | 3 periods |
| Ordnance | 2 " | Ordnance, Naval Architecture and Steam | 7 " |
| Steam | 2 " | Physics | 2 " |
| Navigation | 4 " | Mechanics | 3 " |

## SECOND TERM.

| | | | |
|---|---|---|---|
| Seamanship | 2 periods | Seamanship | 1 period |
| Ordnance | 2 " | Naval Architecture, Ordnance or Steam | 6 " |
| Steam | 2 " | Physics | 1 " |
| Navigation & Survey'g | 4 " | Mechanics | 1 " |
| | | English (Public Law) | 2 " |
| | | Navigation | 2 " |

During the last two years the conduct of Midshipmen at drills, exercises, and on daily duty should be carefully scrutinized by the executive and drill officers. The opinion of each officer for each month should be expressed in a mark, and the combined marks of the different officers should establish a final annual figure, representing the aptitude of the midshipman for the military and practical duties of the profession. In the last year a high value should be assigned to this question of aptitude in determining class standing. I consider it a very grave defect in the present system that the fact of a midshipman's displaying in a marked degree the qualities of a "good officer," attention, alertness and force, has no effect upon his standing. On the contrary, inertness, indifference, or failure to control those under him, do not in the least damage him.

I have thus traced the course, both of studies and practical exercises, which would constitute the education of a midshipman up to the time of his graduation from the Academy. It is not desirable, in an essay of this kind, to go largely into details, nor to defend such details as may have been laid down; nor is it to be expected that any one man will be likely to deal satisfactorily with so complicated a subject as the

details. I therefore here leave the Academic course with the following résumé of my general plan.

1. A low standard of acquirement for admission.

2. All admitted to form one Corps of Midshipmen.

3. The course for the first two years to be as far as possible simplified and to be common to all.

5. At the end of two years, retention only of so many as are yearly required to fill vacancies in the grade of Ensign, and the separation of those who remain into three Corps; Engineers, Ordnance and Sea Corps. The education of each corps to be as thorough as possible in its own specialties; Seamanship, Practical Gunnery, Navigation, Astronomy and Surveying being the specialties of the Sea Corps; Ordnance in all its branches of the Ordnance; Naval Architecture and Marine Steam Engine building of the Engineer Corps. At the same time each corps is to receive such instruction in the specialties of the others as may be necessary and possible.

5. The last year of the Sea Corps to be wholly given to professional and largely to practical work.

6. Aptitude for service and officerlike bearing to have an effect upon class standing, i. e., upon future rank.

7. The pay Corps to come from the Sea Corps.

After graduation the midshipmen should have the usual leave, and then be ordered to sea-going ships for one or two years' sea service; during this period to be called midshipmen. I would have the Navy Department direct that during this first cruise, the commanding officer should assign each to duty as watch, navigation and engineer officers in turn, and for such periods as may be deemed best; and on leaving the ship should, in the usual letter, state what opportunities have thus been given him to continue the education begun at the school.

At the expiration of the cruise, the examination now customary to be held before a mixed board, taken from the Service at large and the Board of the Academy. I do not approve of the present system, by which these examinations are held by the Academic Board alone. The result of this examination, combined with the class standing at graduation, should finally determine lineal rank; unless in one contingency yet to be mentioned. A failure to pass should, as now, cause the midshipman to be dropped to the following class.

A serious difficulty will before this be seen by the reader of this paper. How is class standing in one class to be determined among men whose studies are different?

There is but one answer. When the studies are common to each, though pursued in different degrees, as Seamanship and Steam, the common value will obtain in each case. When the studies are peculiar to one Corps, give them value as an elective course, or perhaps more justly let them serve only to determine standing between men of the same corps.

After the final examination the officers of the Engineer and Ordnance Corps would not be expected to go to sea for some years. I would have them here take a post-graduate course of eight or nine months, wholly devoted to the mechanical and physical sciences as bearing upon their life work. In this they would of course be required to attend instruction, but not to recite. An examination would be held at the end of the course, which, if satisfactory, would involve no change of rank; but failure should be followed by dropping to the following class.

The Sea Corps should similarly have a post-graduate course in the manufacture and handling of torpedoes, with such preliminary instruction in Chemistry and Electricity as may be necessary.

Having successfully passed these last named examinations the education, as far as it depends upon direct external pressure, will be finished; the rest remains with the man himself.

Their commissions as Ensigns would now be issued, and dated back to the time of the vacancies filled; provided such date should not be earlier than two years after date of graduation.

It may perhaps be not out of place to mention two advantages, not directly educational, which I hope for from this scheme.

I. Economy to the Government.

1. The total number of Midshipmen is reduced from that now existing by the number of Cadet Engineers i. e. nearly one hundred.

2. The number of officers on board ship will be diminished through all being eligible for military service. Take for example the number of officers other than surgeons, above the grade of Ensign, necessary for a ship having two divisions of guns.

| PRESENT SYSTEM. | PROPOSED SYSTEM. |
|---|---|
| 1 Captain, | 1 Captain (Sea Corps) |
| 1 Executive, | 1 Executive (Sea, Eng. or Ord.) |
| 1 Navigator, | 1 Navigator (Sea Corps). |
| 4 Watch (and Division) officers, | 2 Watch & Div. (Sea, Eng. or Ord.) |
| 1 Paymaster, | 1 Watch and Paymaster(Sea Corps) |
| 1 Engineer, | 1 Watch & Eng. (Sea, Eng. or Ord.) |
| 9 | 7 |

In addition to which it will be remembered that in case of accident to the Engineer, who by the proposed system is an officer of the Sea Corps, his place can be filled by any one of the others. Under the existing system, the line officers not being considered capable of assuming charge of the engines, two engineers, at least, would probably be found on board a vessel of this class.

II. There would, among the officers graduated, be but one line of rank, in which each man's place would be indisputable. From whatever Corps they came they would, in joining the ship, take the quarters, duties and privileges to which their lineal rank entitled them. All would be seamen and all military men in the strict sense of the word, capable of training and commanding armed men. All would be likewise capable of assuming charge of an engine. Under these circumstances there would be good reason to hope that disputes about the right to give, or the obligation to take, orders, would largely disappear; and corps jealousies, if they still existed, would assume a form less injurious to discipline.

In conclusion of this part of my subject: It is now over a quarter of a century since the United States Naval School was founded, with a view of providing officers with better instruction than the circumstances of a ship afford; but still always with the object of making them simply better officers. Instruction, naturally and properly, has fallen into the hands of men who devote to it their whole time; or at least so large a portion of their time as to become identified with the school. This is right and necessary, for instruction is best imparted by men who thus give themselves to the business. Nevertheless, the instructor, like other men, tends to magnify his office and to mistake mental acquirements, which are simply a means, for an end. This may be bad anywhere, but, from my point of view, it is certainly and specially bad in training for a profession like the Navy, in which mere knowledge is the least of an officer's needs. Such a mistake has been gradually growing in our Naval school, and many of the younger officers of the service, under the name of science, are maintaining the idea that an extensive knowledge of mechanical processes, and an acquaintance with the elaborate mathematical reasonings involved in the investigation of problems connected with the materials placed in our hands, notably ships and ordnance, are essential to every future naval seaman. This is as unreasonable as the objections of older officers to any systematic instruction on shore. It is even worse, for it tends to substitute for a seaman's training a habit of mind and life entirely

alien to it, and probably in most cases destructive of it. It is time for a reconsideration of the whole matter, and I believe that the solution is to be found in a cordial recognition of special corps, all in the line of the service, complementary of each other and not, as now, tending to mutual destruction.

## II. Men.

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The education of seamen must be governed by the same ultimate considerations as that of officers, viz.: What do you want to make out of the material placed in your hands?

There are two principal qualifications which are desired in every naval seaman: That he should be a seaman, and that he should be, to some degree, a gunner. In addition to these are those habits of neatness, regularity, discipline and respect for law, which we look for, but do not always find, in a man-o'-war's man.

If we are to undertake a regular system of training or education, and depend upon that for the whole, or for a chosen part, of the crews of our naval vessels, some degree of mental cultivation is necessary. It is easy, however, to exaggerate the amount desirable.

It seems evident, on the one hand, that the long periods of comparative idleness in port or even at sea, which are now too often the parents of discontent; which lead to desertion, gambling, quarrelling, rum drinking, might be made less tedious if the seaman had acquired a taste for reading books connected with his profession, with the countries he visits, or any other healthful and interesting subjects.

On the other hand it seems plain that if the Government devotes the time of the naval apprentice to acquiring knowledge above the position he is to occupy, more particularly should so use that time as to fit him for the position of an officer of a merchant vessel, it is assuring itself the disappointment of seeing its trained men leave its service for other occupations.

It is, however, neither as seamen nor as artillerists that we principally see the need of training for naval seamen. It is their moral tone that most specially calls for education and elevation.

This failure of moral tone is seen most markedly in two things. As a rule they attach no idea of moral wrong to the violation of a contract, hence desertion. Equally they have no sense of their simple dignity as men, nor of the beauty of self control, hence drunkeness unaccompanied by any sense of shame. In these two cardinal points,

the two greatest evils of the Navy, they acknowledge no duty; to themselves in the last case, to others in the first.

Now I do not hope for a sudden change of sentiment and morale in a large class of men. Doubtless we must wait here for time to do its work in raising the tone of this community as it has that of others; but still the work may be hastened by persistent judicious effort to instil a sense of right and of self respect, especially if we begin with boys. The experience of more than a century has pretty well settled that severity and punishment will not stop desertion nor drunkeness. There are some who seem to think that petting will do it, while others have faith in preaching; but naval officers know pretty well that it is not necessarily the severe man who fails to gain the confidence and willing obedience of seamen, nor the indulgent coaxer that necessarily wins their good will and respect. The cause of the cheerful obedience, which one receives and another never elicits, is doubtless in that secret sympathy which the heart is quick to recognize, and which can neither be counterfeited by fair, nor concealed by harsh words. If we are to have a system of training for naval seamen, no officer should be entrusted with a share of it who is known to be one of those who "can't get work out of men," however indulgent or kind tempered he may be.

The calling and duties of a seaman are essentially of the nature of a handicraft. Quickness of eye and manual dexterity, seconded by activity and strength of the whole body, are involved in everything that he does; and very little else except native intelligence is required for making an excellent sailor. This is sufficiently shown by the admirable class of seamen of the old school, than whom no more efficient men could be found. They were intelligent doubtless—a fool will never make a sailor; but their great skill was acquired simply by practice without any pretence at education; picked up as we say. Now there can be no doubt that systematic training will produce a given result more quickly and in a greater proportionate number of instances; I am, therefore, strongly in favor of it as a means, the more so as along with the seaman's skill can be conveyed that of the artillerist, in which the men-of-war's men were inferior, as well as the development of the moral and intellectual powers which will tend to make the man more trustworthy, and more capable of rational happiness, than the typical seaman of old. Still we must, as with the officer so with the man, steer clear of the mistake that each accumulation of knowledge will give the Government a better servant; which is our true end.

From what I have said, the general course I would follow can, I

hope, be inferred. An apprentice system is desirable, because the lads can be more readily moulded, can more readily be attached to the service at an early age. It is not to be hoped that they can become better seamen than those of former days, but the requisite knowledge can be more quickly acquired. Ordnance is a much more complicated subject than it was; with the peculiarities and liabilities to derangement of the weapons they will have to use they should be thoroughly acquainted. As marksmen they should be as excellent as possible, though it is obvious that a man otherwise good should not be rejected for a defect here. Habits of personal cleanliness, handiness in making and caring for their own clothes, a knowledge of cooking such as will ensure both good quality and all practicable variety in the food, dancing, music, a knowledge of games, and, if there is any other thing which will tend to make ship life more enjoyable, all these should form part of their education. The radical difficulty with seamen, and above all with naval seamen, is that the life is unnatural; this must never be forgotten in considering this question of education. The difficulty is a moral one. The seaman lives without the constant solace and restraint of family life. This want, perhaps, can never be wholly supplied, but everything that tends to make up for it is a means of education to the individual and to the entire class. Combined with such provisions as the above for bodily and social enjoyment, I would provide means for healthfully occupying the mind. As all who pass through any system of apprenticeship will be taught to read. I would direct their reading as far as possible, so as to form a taste that should be not only healthy, but should coincide with the circumstances of their calling. As they will be much in foreign lands, lead them to such knowledge that they will no longer find the grog shop and the low dance house the most interesting features in a great city. Arithmetic enough to keep their accounts is good; but beyond that, time were better spent in learning languages, reading books of travel, of natural history, in short, acquiring knowledge that will enable them to enter naturally, intelligently and with interest into the life they may find around them. Devoted to a noble profession, they may find not only interest but a source of high aims and enthusiasm in naval biography and history. Novels they will read of course; but may it not be possible, in part, at least, to save their taste from falling into the yellow covered pit they now affect. In sketching this outline I don't undertake to say that all this can be done; I only claim that in the way of intellectual culture it is preferable to much that may at first glance seem more

akin to our aims, as for example navigation; and I also claim that it will all tend to increase that reliability and sense of responsibility, to nourish which is, far beyond professional dexterity, the difficulty of the naval trainer. It will do this by raising the man's standard of right, and by helping to fill the void which, we must confess, a man's heart and brain do now find in the daily life of a common seaman.

Hence, to educate a body of seamen, who should form the nucleus around which our naval organization should gather, I would receive into the service a number of boys from fourteen to sixteen years of age. I do not myself attach importance to the nationality of the lad, excepting in so far as the national temperament is or is not adapted to a naval life. Other things being equal, I would reject an Irish or French lad in favor of an English, or one of the Scandinavian race; but an objection to a foreigner as such seems to me misplaced in a country so many of whose citizens are foreigners; the more so as a seaman will commonly lose sight of home ties and attach himself to the flag under which he sails. The lads thus received should be distributed in training ships, whose officers should be chosen by that practical test of being those "for whom men will work." Yet more important, if possible, than the officers, are the seamen who will be stationed on board these ships; the leaven for the lump. To my mind it would be, as a rule, a mistake to choose these from elderly seamen, however admirable their general character. Probably there is no more outrageous conservative than the ordinary old seaman; to allow such to steep a rising generation in their prejudices is simply to start that generation some twenty years behind the point at which they should begin their race. Although the character of seamen generally has advanced slowly, as compared with the progress of the world at large, still it has advanced; and the change in the main has been for the better. Let the lads then be surrounded by the best you can get, but by young men, from whom they will imbibe the best of the spirit of the age immediately preceding their own. Above all, don't make these ships the refuge of old age, however worthy.

The regulations of the department should provide against boys of vicious character being retained, as they already do against physical disability. The life should be that of a model ship of war, yet so contrived as to work in continually the systematic training by which the necessary knowledge will be steadily imparted. I mean by this that mere training is defective, unless accompanied by the daily habit of life of a real ship of war; that a special habit of life in training, differing

materially from that to be pursued afterwards, is to be deprecated, unless necessary; and the necessity here seems to me to point the other way. A relatively large portion of time must, it is true, be passed in port, as the exigencies of the sea interfere too much with regularity; but I would pursue the ordinary routine of a ship of war, which affords sufficient time for the exercises of sails and guns, and instruction about them in their various details. The other portions of the day would be devoted to other instruction: marlinspike seamanship, cutting and making up clothes, cooking, carpentering, sailmaking, &c. Long before the period of apprenticeship has passed, special aptitudes, when existing, will have been recognized by the officers, and it will be wise to make use of such natural bent. I do not myself see why the Engine room force should not be partially recruited in this very way as well as by direct enlistment for the purpose; and it may well be that some instruction in the engine and fire room would be of advantage to those intended mainly for the deck. My principle for officers is general instruction in all branches, special knowledge of one and I would apply the same in the end to the crew; though I am not as sure with them as with officers, that the time for so doing has fully come.

As regards the cultivation of the mind, I must adhere to my first position that the seaman is above all a handicraftsman; and that such culture as may be imparted should have for its chief object the development of manly self respect, true professional pride, and a high sense of duty; after which, and barely secondary to it, is healthful occupation for the mind, and capacity for enjoying much to which, as yet, the seaman's eye is blind. Thus surely the tone of the man will be raised, and he will be more reliable than now. In giving the various kinds of instruction alluded to, an officer, whose heart is in his work, will be careful to see that the reasons for this and that are explained. Thus, the effect of cleanliness of the person and of the ship upon health, will be pointed out as each is insisted upon; so in the carpenter's gang *why* one kind of lumber is good for one purpose, another for another, why one method of working up is more advantageous than another, I do not propose to lay out a programme or routine in this paper; the general subjects of which I have spoken can, I feel sure, be worked in by a man of fair executive ability during the time the apprentices are with him.

The question of sending the youths out into the general service before their time is out is a difficult one. I incline to think it best not to

do so at any rate before nineteen; that is. two years before the expiration of their time. Even that is over young, until the tone of the seamen in general service shall stand higher than it does now. Scruples about desertion, drunkeness, and cleanliness, beyond a certain point, would meet with too scant sympathy as yet; and I doubt whether the majority of the lads could stand against the force of the popular estimate at an early age. On the other hand, it may be urged that it is most necessary that they should have some general service, and not remain too long in leading strings. My own recommendation is to put it off as long as possible, and then try to choose your officers and crew. The entrance upon life is everywhere a critical time; how much more here, where home ties can scarcely bear, where temptation is strong, and the standard of equals generally too low.

When embarked in the service but still regarded as apprentices, care should be taken to stimulate their interest in the scenes amid which they pass, and to free their life as much as may be from the listless aimlessness in which too many seamen pass their days. But when the training ship is left, the power of choosing officers is greatly diminished; and the increase of privileges for men, such as more constant access to shore, greater command of money, and such like, must be a matter of gradual growth. However greatly we desire to see such indulgences multiplied, and however superior the ideal state for which we look, we cannot shut our eyes to the fact that progress here, as well as in other things, to be healthy must be gradual; that some officers though admirable generally, have not the knack of combining indulgence with strictness; and so, while something may be done by system and regulation, much must be left to the tact of the Commander. An impatient tendency is sometimes seen to reach desired ends by hard and fast rules, by general regulations, which cramp unduly that free action of the commanding officer upon which the efficiency of a ship must ultimately depend. It is wiser, here and everywhere, to wait for the gradual change of opinion in officers, and rise in the character of seamen, which a patient eye can surely detect now, and which will in good time bring about all that is really desirable. In any event, whatever the rule of the ship, let that, neither more nor less, be the rule for the apprentices on board her. No indulgences because they are apprentices, no keeping them as children under special evident care. Whatever their superiors may do, let it be by quiet watchfulness, by individual caution or encouragement, just such as they would extend to an older man. In a word, if being the commander or

first lieutenant you wish to look out for them, don't let it be by making a special *class* of them, whether for care or indulgence. To do so will not only create prejudice against them among the rest of the crew, but will probably act harmfully upon themselves. The only distinction I would make would be that, being intended for seamen, they should do only seamen's duty; not messenger boy's nor berth deck cooks'.

In conclusion: It has been often said that the English speaking races find their strongest motive in the sense of duty. If it be really so, it is a high privilege which those races enjoy that they respond *instinctively* to the noblest appeal that can be made to man; and for both officers and men it will be the task of the teacher to cherish and develop that instinct, bringing it to play not only in times of danger or hardship, to dare and to bear, but also in daily life, in little things. So men shall recognize duty not only where she calls aloud, demanding life or happiness, and all hear her; but as well in those quiet daily rounds, when her voice is so low and so monotonous that men scarcely think that duty is there at all. The man who walks daily with her and obeys her voice must be the most sure not to fail when she asks for more. Yet even to the most steadfast this path of duty is often very hard, and in it they find little sympathy; men do not recognize the difficulty, which sometimes exists mainly in the man's own nature; they know so little they can make no allowance for failures, nor appreciate the actual amount of work done. Here it is hard for man to stand alone, and yet he too often finds none to stand by him. So I think any scheme of education is defective that makes no effort to teach the learner to believe in and to depend upon God; to bear constantly about him the consciousness of one perfect friend who knows just how painful it often is to *him*, just how faithfully he had worked when to men he had seemed to fail; and who, however men may judge, gives credit for all and will not let seeming failure be failure in the end. The power of such a conviction is matter of history, nor, whatever may be claimed in special cases, nor, however we may be deceived by the results of natural energy and ability, do I believe an ordinary man is at his best without it. Unfortunately too many who seek to implant this reliance cannot avoid cant, the endeavor to make up for their own lack of conviction and feeling by strained words, which themselves betray their unreality; and the result is the very general discredit of an actual power. At the end of my "Essay" upon the education of these youths I urge the necessity, even as a matter of policy,

of placing among them a chosen man or men who can instil into them that faith which will give completeness to their training. This, when in perfection, ensures that all the other education, all the courage, all the faculties of the man will be brought to bear on every duty placed before him; alike when unseen as when seen by men; alike in the steady, weary drag as under the stimulant of high action and danger.

# THE RECORD

OF THE

# UNITED STATES NAVAL INSTITUTE.

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## U. S. NAVAL ACADEMY, ANNAPOLIS,

April 10, 1879.

Professor J. Russell Soley, U. S. N., in the Chair.

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## DISCUSSION OF THE PRIZE ESSAY ON NAVAL EDUCATION.

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The Chairman. The meeting this evening has been called for the adjourned discussion upon the Prize Essay on Naval Education, by Lieut. Commander Brown. It may be well, therefore, to give a brief summary of the points presented by the essay.

The essay begins with the assumption that the education of a naval officer should begin at a school, and not as was formerly the case, on board cruising ships. This theory is now universally applied as far as I know, in the navies of the world. The German and Danish navies are only partial exceptions, in both of which a cadet begins his career by a short practice-cruise in a training ship,—a very different matter from performing regular duties, at the outset, in the ships of the fleet.

For the Academy itself an alteration in the method of appointing cadets is proposed, involving a general application of the system of preliminary competition. Lt.-Commander Brown renews the admirable recommendation of Admiral Rodgers, to obviate the difficulties of the Academy consequent upon a large number of deficiencies, that a partial graduation should take place at the end of two years, after which only the best men should be retained for further instruction,—a plan that would secure only the best men for the service.

The subject of naval education is closely connected with that of organization; and accordingly the essay proposes some radical changes in this direction. The essential feature of the proposed plan, the corner-stone upon which the whole scheme is built up, is the absorption of the Engineer, Pay, and Marine Corps in the Line, and the performance of their duties by line officers, specially detailed for the purpose. To give them the needful training one year is to be added to the course at the Naval Academy, and the additional time thus gained is devoted to those studies which are now followed by engineers exclusively. A two years' cruise at sea is followed by a course in Torpedoes and Steam, at Newport, and by a further cruise as watch-officers. On the completion of this cruise, officers are to elect the special duty for which they desire to be detailed. If they make no such election, their career remains the same as that of the present line officers. If they elect pay duties or marine duties, they are assigned accordingly to ships and shore stations. If they elect engineer duties, they return to Annapolis for a two years' course in Steam-Engineering; after which they are ready to be detailed for service in the capacity of Engineers. They do not,

however, lose their character as line officers, or their place on the list; and they revert to the duties of the line, on their promotion to the higher grades.

Three permanent corps are established, the Engineer, Pay and Marine Corps, with officers of the grades of Lt.-Commander and above; and vacancies in these corps are filled by competitive examination among those line officers who have served two details at sea, in performing the duties of one or another branch of the staff. In the permanent Engineer Corps are also included the Constructors; and officers in the two lower grades of this corps are to be sent to sea.

The changes in organization are to be begun by the cessation of all appointments in the lower grades of the staff corps, and the extinction of the upper grades by the natural process. To hasten the change, however, an option is given to the present Passed Assistant and Assistant Engineers of the relative rank of Lieutenant, Master and Ensign, of remaining in their corps, or of being admitted to the line, upon passing the regular line officer's examination for promotion to the grade in question. If, however, they fail in the examination or decline it, their promotion ceases beyond the grade of Passed Assistant Engineer; and if they pass they are placed at the foot of the grade into which they are admitted. It can hardly be denied that such a provision would operate with excessive rigor upon these officers, especially upon those who are now Passed Assistants, with the rank of Lieutenant. They are men of mature age,—some of them upward of 40,—and their prospect of promotion is a vested right, which they have long and justly counted upon. It is proposed either to take away this right of promotion or to make it contingent upon passing one of two examinations: the first, a competitive examination for the permanent corps, from which many men will necessarily be excluded; the second, a test examination for the line, in seamanship, gunnery and navigation,—three comprehensive subjects, which are, to a great extent outside of their professional training; and this at a time of life when a knowledge of new subjects is not readily acquired. And if they succeed in passing this difficult test, they are to be placed at the foot of the list of Lieutenants, two hundred and eighty in number, most of whom are ten years their juniors in age, and all of whom are their juniors in rank. Perhaps the simplest method of avoiding this measure would be to allow the Engineer Corps to be extinguished by natural causes, in the way proposed for the pay and marine corps.

With regard to the Education of Men, the essay is confined to a general approval of the apprentice system, to a recommendation that Machinists should become Warrant Officers, and to suggestions as to Messes and Cooks, and the duties of marines on shipboard.

Scuh are the principal features of the plan proposed in the prize essay, and it is to be hoped that they will receive the fullest and freest discussion.

Lieut.-Comdr. GOODRICH. Discussion implies difference of opinion. It will be seen, however, that my own tentative solution of the problem of Naval Education is, in its better features, mainly a modified repetition of most of Lieut. Commander BROWN'S statements and suggestions, so that I find myself rather lacking in pegs upon which to hang objections.

Nevertheless, there are one or two points upon which, in particular, I can not entirely agree with the essayist.

First, as to the necessity of what he styles the *permanent portion* of the Pay Corps.

It appears to me that, ultimately, it will be a very simple matter to secure most able administrators of what is now the Bureau of Provisions and Clothing, from the Line of the Navy. It has been said that progress is simplification. I see nothing to convince me that, under the new order of things, the Pay Corps as such will not be wholly superfluous.

Secondly, while at one with the essayist as to the desirability of at once beginning the move which will gradually result in the absorption of the Engineer's function by the Line, I confess to entertaining a grave doubt as

to the justice to the Midshipman graduate of the Naval Academy of summarily putting a number of men in between him and the higher grades of the service. Did not the condition of affairs, at the time of his entrance into the Navy, involve a tacit agreement that such things as this, at all events, should not be done to lessen the value of the prize held out to him?

Thirdly, I take it for granted that the Commander Engineer is not to go to sea in command. I had hoped that the number of officers of high grade on board one ship would be lessened materially through this essay.

I have been thus frank that I might with more weight add to the essayist's remarks upon the course of Instruction at the Torpedo Station, the further suggestions, that the subject should be included in examinations for promotion and that, in view of the constant changes in this branch of naval warfare, all Lieutenant Commanders should pursue a course (a second one if necessary) before receiving their Commander's commissions.

The proposed officering of the Marine Corps and the increase in the number of marines allotted to a vessel must be regarded as a happily contrived scheme for increasing the efficiency of both guard and ship; I say nothing of the material comfort introduced. The change in the *status* of machinists is merely the recognition that something must be done to attract to and retain in the service, men who are really worth the liberal wages now so often squandered on inefficient and intemperate bunglers.

I am sure that the objections urged in the discussion will as a rule be directed against the details rather than against the plan as a whole. That plan will be felt to embody the wants and aspirations of the service at large and will be welcomed not only for its immediate value as a permanent and important contribution to the literature of our profession. I sincerely hope the time is not far distant when we shall all rejoice in belonging to a homogeneous Navy modelled largely, if not entirely, according to the suggestions of this essay.

Passed Assistant Engineer ROBINSON. It was with a great deal of pleasure that I listened to the valuable, and interesting paper on *Naval Education* read by Lieut.-Commander BROWN before the Institute, Thursday evening, March 27.

It is a well established fact, by comparing the present with the past, that to increase the education of the naval officer is to increase the efficiency of the navy; and it is equally apparent that any improvement in the education of the naval officer, should not be confined to one class of officers, but should be extended to all, with such modifications as the special nature of their respective duties might demand.

I deem the major part of Mr. BROWN'S essay as worthy of the greatest consideration, and as being an important step in the right direction, although there are some points on which we must disagree; and as they are mostly concerning that part of the naval organization in which I am professionally interested, I will confine my remarks mostly to them, touching slightly upon matters of general interest, and leaving the representative men of the other branches of the service to take care of their part. I cannot see any just reason, however, why the Surgeons should be an exception to the general scheme of naval education. Why should not the young naval medical student be instructed as well in the service, as out of it? Is it because the senior medical officers of the navy are incapable of teaching them? I think not, and believe that they would receive a better training for that special kind of service in which they are expected to distinguish themselves, than they do at outside institutions; and that the establishment of a naval medical college or department at the naval academy would be of advantage to the service, and require very few more officers to conduct it, than are required to perform the present duty. Four years at such a school, where they would receive the benefit of the experience of naval surgeons, would certainly better qualify them for the service, than two years at any outside college, which I think is ample time to obtain a diploma at the most of them.

England, if I am not misinformed, has a military medical college at "Netley" on Southampton Water, where the medical officers are instructed for both the army and navy.

Mr. BROWN shows how the officers of the navy are divided into line and staff, sets forth in detail who belong to the latter class; then reduces his system down to the education of one class of officers, and these are required to know about everything worth knowing.

From this class are to be detailed officers to perform the duties of Paymaster, Engineer, Constructor, Navigator, &c., as may be required in "a manner to conduce to the harmony of the service, and the good of the country." As to whether this system would eradicate the implied want of harmony in the service—which we recognize as that existing between line and staff, or not—is an open question.

I believe that it would to a certain extent, but not wholly. It would in this way; the officers, for instance, performing duty in the engineer's department, would be drawn from the same original source as those performing duty on deck; consequently, the latter would have less desire to interfere, and the former would possess greater ability to resent encroachment. And in addition to this, the commanding officer, in deciding points of disagreement that might arise, would not be influenced by the prejudices that now exist; and the representative staff officer would not have to seek justice at the hands of a hostile commanding officer.

Cases of interference would arise then, as they do now, probably not so frequently, and they would be more easily settled on the basis of *right* and *wrong*, instead of *corps prejudices*.

There is a way of producing harmony in the service between line and staff, a very simple one, one that is much desired by staff officers, and one that could be easily brought about, as I shall endeavor to show further on.

I believe with Mr BROWN, that the duties now performed by the Paymasters, could very readily be performed by other officers, for instance, the *lieutenants*, with very little extra training; but whether this would be a wise policy or not, I will leave for wiser heads than mine, or for the guardians of the public funds to determine.

Paymasters, at times, have in their possession large amounts of public money, and as human nature is weak, the Navy Department has found it necessary to place them under heavy bonds. As we have no right to expect a higher standard of honesty among the line officers than among the paymasters, they, too, would have to give *bonds* when detailed to perform this responsible duty. But the department might experience some difficulty in compelling an officer to give bonds in this case. What if he declines and says, "I will perform the duty but not give *bonds*"? I see no way of compelling him to do so.

Should this scheme be deemed advisable, it would only be necessary to add to the course of study at the Naval Academy, book keeping; this should be of a character to suit naval accounts, and should be taught to both the cadet engineers, and cadet midshipmen.

The number of officers of the Pay corps is so small, that such a change could be brought about in a few years, without injury to any one, by stopping appointments to that corps at once.

Officers to perform the duties of Marine Officers on board of ships, could very readily be detailed from the line, and they would require very little, if any, special training, as they already perform the same sort of duty. Thus the present method of furnishing vessels with marine officers, could be allowed to die out, but with it the "*esprit de corps*" of that branch of the service, and much of the military character of a man-of-war.

I do not think that the proposed Jack-of-all-trade system would conduce to the good of the country.

The example of progress in the sciences and mechanical professions shows, distinctly, that the tendency is towards specialties, and *to this* tendency is due the vast strides in improvement and invention.

No *one* head is capable of holding all that Mr. BROWN has shown to be necessary to the efficient line officer, in addition to what is required by an engineer to keep up to the times in his profession, even without adding to the country's good by original production.

I have found that there is more in my profession than I am able to master, and I believe that the line officer will find all that he can manage if he follows the programme laid out, without *attempting* to become a competent Engineer. I do not wish to be understood as, opposing the system of instructing line officers in steam engineering. I believe the decision to give midshipmen a course on marine engines a wise one. It has been my experience, and I know it has been the experience of many others of the corps, that the commanding or other line officers who possessed a good knowledge of the steam engine, were the easiest to get along with, the least likely to interfere, and are not the ones to give orders to the chief engineer to carry twelve pounds of steam on one boiler and twenty pounds on the other to favor the weaker boiler; nor to scrub his engine room floor plates with sand and canvas. Such an officer would say "I want to do so and so; you know best how to do it, go ahead and do it;" thus trusting to the engineer to manipulate his boilers and engines to the best advantage, and it would be done; for there is no better method of making efficient naval officers, either line or staff, than to place confidence in them, and hold them responsible for the result; and there is no better way of making timid officers than to show a lack of confidence in them.

To return to the subject of professional qualifications, it seems to me that the naval constructor, who makes himself master of all the methods of designing, laying down and constructing iron and wooden ships, and keeps up with the progress of other countries in this particular, has no time to become proficient in navigation and seamanship; if he has, the time might be well spent in seeking improvement in our present methods of ship building, as there seems to be some room in that direction.

I would therefore reduce the classes of officers to be educated at the Naval Academy to the line and the engineers; possibly the surgeons. From the line would be detailed the officers to command the Marines on board ships, and from the engineers would be selected the constructors, consulting as far as possible the natural inclination of the cadet.

The pay officer for the cruise might be detailed from either the line or the engineers as their qualifications in that particular would be the same.

The present course of instruction at the Naval Academy, though a good one, I believe, with Mr. BROWN, could be materially improved. A good practical course on *Iron Ship Building* should be added to the Department of Steam Engineering, with the means of building a small vessel.

The addition of another year to the course, might be of advantage as the time seems too short to accomplish all that is desired. That some alterations are necessary in the present programme of studies, seems to be a fact recognized by many of the instructors.

In all studies not professional the cadet engineers and cadet midshipmen should be as one class, and the cadet engineers should participate in all military drills, except during the last year when they should be excused from all drills, the time being given to shop service.

I see no good reason why the cadet engineers should not participate in the boat drills; if there is any reason why an engineer should not know how to pull or sail a boat, I am ignorant of it. It has been my lot to have to take charge of a boat a great many times during my career of nearly eighteen years in the service, and at first I experienced great inconvenience from the want of knowledge of the subject.

The last two years of the course should be confined as far as possible to professional studies and practical exercises.

The method of appointment, accompanied by a competitive examination is a good one; and the idea of a two years preliminary course prior to the

selections for the service is an excellent one, as it would most assuredly obtain for the service the best material to be had.

The proposed plan of absorbing the engineers and constructors by the line, I consider impracticable, unnecessary and undesirable, for reasons already set forth. It would not only fail to conduce to the country's good, but would work a palpable injury to the service from which it would take years to recover. Allowing the average ability in the engineer corps to be near that of the line, what benefit could the country obtain by replacing officers of from fifteen to twenty years practical experience and hard study by others of but a few weeks of elementary instruction. It would largely increase the number of line officers, and with it their prestige and power, and would practically destroy the engineer corps as an organization.

To bring about this state of affairs, Mr. Brown proposes a system of amalgamation. We will examine this method and see what effect it would have upon the present engineer corps.

Mr. Brown says, "as regards the engineer corps we may well take a lesson from the French Service. The engineers should be the '*Corps d'élite.*' The scientific men of the service should there find their appropriate place. They should be also the constructors, uniting in their corps the offices of designing and construction of vessels, as well as the machinery to propel them."

This sounds excellent. He then proceeds to establish what he terms the permanent portion of the corps, consisting of one (1) Rear Admiral—Engineer in Chief; two (2) Commodores—General Inspectors—for the Bureaus of Engineering and Construction; twelve (12) Captains for Constructors and supervisors of engineering works outside; twelve (12) Commanders for Chief Engineers of the Yards, and twenty-five (25) Lieutenant Commanders to be Chief Engineers of first and second rate ships and to assist the Chief Engineers and Constructors at the yards; as there are usually more than twenty-five first and second rate ships in commission it would be difficult to provide for them, and render much assistance to the Chiefs at the Yards, without considering the subject of reliefs. However, he thus provides for fifty-two (52) of the seventy (70) Chief Engineers now in the service, and does not say what is to be done with the rest. These inducements might tingle in the ears of the older chiefs, and secure for the line an able ally to work the destruction of the lower grades, but we will hope for something better.

Leaving eighteen (18) Chief Engineers with the rank of Lieutenant Commander unprovided for, we will proceed to examine the proposed method of disposing of the Passed Assistant Engineers with the rank of Lieutenant of which there are over eighty (80), at present. Over seventy (70) of these are entitled to their promotion to the grade of Lieutenant Commander in their own Corps by the regulation under which they entered, and have been for many years. Nearly one half of them entered the active service in the year 1861 as contemporaries of over thirty (30) of the present commanders of the line, and with them rendered the country good service during the late war, but fell far short of receiving corresponding rewards.

It is proposed to examine these officers with a view of transferring them to the line, a branch entirely different from the one in which they have been trained; and if they fail to pass the examination, promotion ceases, disregarding their qualifications to perform the duties of their own corps, and they are virtually retired, if not actually driven out of the service, at a time in life too far advanced to commence another profession, and entirely unfitted by their naval life to embark in any such adventure.

They would be required to pass the examination now passed by a master—one entirely unprofessional to them, and if they were successful what might they expect? Judging from the example of the volunteer officers who were transferred to the regular line after the war, they might expect to be placed at the foot of the list of over three hundred lieutenants, and junior to hundreds of officers whose whole time of active service is less

than that which many of the Passed Assistant Engineers have already been entitled to their promotion to the grade of Lieutenant Commander.

If they fail to pass the examination, promotion ceases by virtue of their failure; if they pass, promotion is placed so far off that not a single one would live to reach it.

Where is the inducement for a man of forty-five, to enter the school of navigation and seamanship for the purpose of competing with the young man fresh from the Naval Academy? I think but few would attempt it.

Having passed the examination successfully, and been accepted as junior lieutenants in the line, they are to be detailed back to perform the very same duties they now perform, and wherein has it conduced to the good of the country? It certainly has not conduced to the good of the officer most interested.

Returning to the subject of restoring harmony in the service, it occurs to me that the first thing necessary is for every officer to render his individual assistance. Let the line cease to term the staff civil adjuncts, non combatants &c., and recognize the inevitable truth that in a military organization all things are military.

Two officers appointed by the President, by and with the advice and consent of the senate, receiving commissions struck from the same block, with the necessary blanks filled in with their names and respective professions, cannot differ much in their military status.

I fail to see why the officer who gives the order to the man who turns the wheel, to make the ship go starboard or port, is any more military than the officer who gives the orders to the man who turns the wheel to make her go fast or slow, or why the officer who gives the orders to the man who manipulates the machinery to train the gun, is any more military than the officer who gives the orders to the men who manipulate the machinery to turn the turret that contains the gun, or why the man who shovels coal into the furnace during action is less military than the one who shovels powder into the cartridge.

The duties on board ship should be well defined, and no officer should be allowed to encroach upon the legitimate grounds of another. Let the line officers, navigate, sail, and police the ship, the engineer, engineer her, the paymaster perform his duties as commissary and paymaster, and the surgeon exercise his sanitary functions as health officer. Let the commanding officer decide impartially by the law of the land, and hold the head of each department responsible for the efficiency of that department, as he alone is responsible to the Secretary of the Navy for the efficiency of his ship.

As the Bureaus in the Navy Department are to the Secretary of the Navy so should their official representatives on board ship be to the commanding officer.

Due respect should be shown to seniority, whether of line or staff; and the controlling influence should be based upon equal rights, justice and impartiality.

Let this system be adopted and I venture to say that harmony would be restored and contentions between line and staff would cease.

A word more concerning the proposed method of furnishing firemen, and I will close my part of the discussion, which has already assumed dimensions beyond my anticipations. Firing may not belong to that kind of labor called skilled, but there are certainly skilled firemen, although they are scarce in the navy, owing to the system of seamen and ordinary seamen extra, with reduced pay when not actually steaming. After the introduction of this plan, I am confident that seventy-five per cent. of the best firemen in the navy at the time never reënlisted, but sought employment in the merchant service. Some of them have been induced to return during the last two or three years by a partial return to the old system. The difference between good and bad firing has a remarkable effect on the coal pile, a fact familiar to every engineer. Firing is almost a trade, men follow it

as a profession, and take pride in their ability to handle a fire to the best advantage. Such men abhor the duties of seamen, as a good seaman does those of firemen.

By the introduction of the plan referred to above, the government saved a few dollars on the firemen's pay but lost many times that amount in the expenditure of coal, due to incompetent firing.

The proposed plan of sending seamen into the fire room to do the firing when required would certainly increase this element of expense, add greatly to the inconvenience and embarassment of the engineers' department, and add nothing to the welfare of the ship, nor to the service at large, except so far as it contributed to the system of general amalgamation, with a view to having but one class of beings on board of the vessel at sea.

Comdr. MAHAN: Before making certain comments and criticisms on the Prize Essay which was read before us a fortnight ago, I wish first to express my own concurrence, in the main, with the *general* plan laid out in it. I adopt heartily as my own the words which I am about to read from it, and which, less ably expressed but otherwise almost verbatim, occurred in an essay which I had myself the honor to lay before the examiners.

"I assume the broad principle that (with the exception of the Medical officer and the Chaplain) *every* officer on board ship should be a combatant sea-officer, a graduate of the Naval Academy, an efficient addition to the strength of the ship's company, in lieu of the present plan, by which many persons of the ship's complement are unskilled and untrained in the use of arms."

And here I may say that I trust, however much at first sight the idea may be distasteful to individuals, that they will endeavor to lay aside prejudice, and to weigh carefully the proposition placed before them, as well as their own arguments against it. As instancing what I deprecate, I may cite words that occur in a letter which I lately received from an officer of sound judgment and much ability: "I have not yet" he says "had time carefully to read the essay, but I don't myself believe in the jack-of-all-trades business."

I believe this particular officer will give consideration, but I fear many will dismiss the subject with some such *ad captandum* argument; I know of one who did so. But we must beware of taking a proverb as an argument, however valuable as an illustration or a simile.

For let us consider just what we are in the Navy now; of how many trades even now are we jacks. Take the matter of sending men ashore as soldiers, are we masters of that trade strictly? Take the matter of law; of that we must know enough for courts-martial and for certain phases of international and prize law: but are we masters of law? If the fair meaning of the word jack be as I take it, to have a useful but not an exhaustive knowledge of any pursuit or handicraft, then we have now to be jacks in many businesses—e.g.: Astronomy, Naval Construction, Electricity etc. It does not follow that because jacks at many we will be master of none. We must not be satisfied without being master in two things, viz.; the handling of our ships and the using of our guns; there our knowledge must be minute, comprehensive, thorough. But I see no reason that being jacks at all the others, and able to manage a steam engine to boot, need hinder us from being master of the one trade which is peculiarly ours.

In this connection the peculiar necessity of our own navy must not be left out of sight. With no coaling stations abroad, we are not yet in sight of the day when we can largely do without canvas. Our ships must for long both steam and sail. The younger officers can therefore be fleeted from the forecastle and quarter deck to the engine room, according to the circumstances, with great advantage; and if the distinction between the engineer and the line corps be done away, pride, instead of distaste as heretofore, will be felt in the management of the engines as well as of the deck. I myself firmly believe that among the lads now here at the school are to be found a plenty who, with suitable instructions and practice, would within

the six years of cadetship become equally valuable, (and by that I don't mean of no use at all), in the engine room and aloft, repairing machinery or handling a boat. If this be so, and this is the gist of the whole matter, incalculable in many ways would be the benefit to the service of the change advocated.

As regards the paymaster's duties, the matter to me admits of no argument. The instances that have come to my knowledge convince me that a young line officer can pick up those duties rapidly and do them thoroughly well.

Having thus had the pleasure of stating my agreement with the essayist on the main issue, I proceed to state certain points, of detail yet essential, in which I differ from him.

First: as to competitive examinations for admission to the school.

My distrust of competitive examinations dates back to my early knowledge of our military school. While the methods of that school are antiquated possibly as compared with some of ours, still, while we claim the merits of youth, we must admit that we have not yet had the opportunity of proving the advantages of our training in the brilliant manner which was offered to the elder institution, though the youth of our graduates, I believe, alone prevented their furnishing such a brilliant array of names as was furnished by West Point soldiers, on both sides, in the late war. The west Point system, if antiquated, has had the crown of success; and of that system unless I greatly mistake competitive examinations and a high standard for admission did not form a part. I remember hearing one of the oldest professors there say that on the whole they were better satisfied to have the youths come knowing little, (a low standard in other words); and as he had not to do with the entering classes he probably spoke the views of his colleagues who had. At all events, whatever the theory, for many years the practice was such.

And after all what does a competitive examination for admission prove? Nothing; except that a boy when you begin his naval training knows so much. It does not prove brains, nor energy, nor perseverance, nor pluck. It only shows who has had the most schooling, or perhaps the most recent judicious and thorough cramming. We all see that clearly enough here at the final examination of graduates; what is that but a competitive examination? And don't we all cry out about that counting too much in comparison with the four years course at the school? Rightly we so do, I think; and yet that at least comes at the end of their naval training to establish rank, while the competitive examination at the beginning really establishes nothing beyond how much a boy has had shoved into his head.

We have, however, here at the school some data for comparing the two systems, although, from the few years that competitive examinations have obtained, the results are not exhaustive of the matter. The cadet midshipmen are appointed without competition, and have a low standard for admission and are younger. The cadet engineers are appointed by competitive examinations, the best twenty-five among all comers; the standard is much higher, and they are older.

To institute a comparison I have taken those studies which being pursued in common are also considered to be the most difficult. In these I take the percentage, out of those who pass at all, that obtain a mark of 3; which by the marking of the Academy indicates "*good.*" I do not take the percentage of those who enter, but of those who pass; because the many who fail and fall by the way do not affect the service of the Government; except by the money they cost. Under a strict rule, this is comparatively little, as they generally drop out in the first few months. The first classes between which the comparison can be made are those which graduated after a four years' course in June, 1878.

The average age on admission of cadet midshipmen was 16.5 years; the average age of cadet engineers of the same class, 18.5.

| | |
|---|---|
| Math. | In the 3d class year 38 per cent cad. mids. got a mark of 3.<br>" 47 cad. Eng'rs "<br>9 per cent. in favor of Eng'rs. |
| Chemistry. | In the 3d class year 46 per cent. cad. mids. got a 3.<br>" 43 " cad. eng'rs<br>7 per cent. in favor of eng'rs. |

Of the same classes in the 2d Class year, ending June, 1877.

| | |
|---|---|
| Mechanics & Applied Math. | In the 2d class year 33 per cent, cad. mids. got a 3.<br>" 43 " cad. eng'rs "<br>10 per cent. in favor of eng'rs. |
| Magnetism & Electricity. | In the 2d class year 47 per cent. cad. mids. got a 3.<br>" 29 " cad. eng'rs got a mark.<br>18 per cent. against eng'rs. |

Of the same classes in the First Class or Graduating Year, ending June, 1878.

| | |
|---|---|
| Naval construction. | In the First class year 83 per cent. cad. mids. got a 3.<br>" 93 " cad. eng'rs "<br>10 per cent. in favor of eng'rs. |
| Heat and Light. | In the first class year 42 per cent. cad. mids. got a 3.<br>" 43 " cad. eng'rs<br>1 per cent in favor of eng'rs. |

Classes that will graduate this June, 1879.

The average age of admission of the cadet mids. was 16.7. The average age of the cadet eng'rs 18.1.

| | |
|---|---|
| Math. | In the fourth class year 42 per cent. cad. mids. got a 3.<br>" 54 " cad. eng'rs "<br>In favor of eng'rs 12 per cent. |

Same Classes, year ending 1877.

| | |
|---|---|
| Math. | In the third class year 46 per cent. cad. mids. got a 3.<br>" 29 " cad eng'rs "<br>In favor of mids. 17 per cent. |
| Physics. | In the third class year 34 per cent. cad. mids. got a 3.<br>" 52 " cad. eng'rs "<br>In favor of eng'rs 18 per cent. |

Same Classes, year ending June, 1878.

| | |
|---|---|
| Applied Math. & Mechanics. | In the second class year 29 per cent. cad. mids. got 3.<br>" 30 " cad. eng'rs "<br>In favor of eng'r 1 per cent. |
| Magnetism & Electricity. | In the second class year 31 per cent cad. mids. got 3.<br>" 39 " cad. eng'rs "<br>8 per cent. in favor of eng'rs. |

Class that will graduate June, 1880.

The average age at admission of the cadet mids. was 16.6 years. The average age of the cadet engineers, 18.7 years,

| | |
|---|---|
| Math. | In the fourth class year 46 per cent. cad. mids. got a 3,<br>" 40 " cad. eng'rs "<br>In favor of mids. 6 per cent. |
| Math. | In the third class year 39 per cent. cad. mids. got a 3.<br>" 47 " cad. eng'rs "<br>In favor of eng'rs 8 per cent. |
| Chemistry & Physics. | In the third class year 33 per cent. cad. mids. got a 3.<br>" 53 " cad. eng'rs "<br>In favor of eng'rs 20 per cent. |

The very great fall in the percentage of cadet mids. attaining the standard adopted by me for comparison, between the fourth and third class year in this class, led me to seek a probable cause. I found then that there appeared on the class list thirteen names which did not appear in the list of those who passed the year before. These names represent cadets who had been found deficient or dismissed, or turned back: names which in every case, without a single exception, swelled the total of the class with-

out once adding a unit to the number who had gotten a 3 in Mathematics. One alone of the thirteen attained a 3 in Chemistry. If we allow for these additions to the class the percentage in Mathematics rises to 51, in Chemistry to 44. The same class of engineer cadets suffered the addition of only *one* incompetent to their number.

Considering that the cadet engineers are from eighteen months to two years older class for class, than the cadet midshipmen, a very undoubted advantage, the run of the percentages may be fairly claimed to show, as far as they go, that no reliance can be placed upon competitive examination to indicate mental capacity, or future attainments.

This may however be even more satisfactorily shown by comparing the standing of cadet engineers, as assigned on admission with that maintained through the course. For this purpose I take the first five of successive classes, as established by the competitive examination for admission, and follow them through the course.

### Class of 1878.

| Standing on admission. | Subsequent standing. | | | |
|---|---|---|---|---|
| 1874. | 1875. | 1876. | 1877. | 1878. |
| 1 | 1 | 1 | 1 | 1 |
| 2 | 10 | 14 | 14 (foot) | 13 |
| 3 | 3 | 2 | 2 | 2 |
| 4 | 15 | Failed. | | |
| 5 | Failed. | | | |

### Class of 1879.

| Standing on admission. | Subsequent standing. | | |
|---|---|---|---|
| 1875. | 1876. | 1877. | 1878. |
| 1 | fell sick. | | |
| 2 | 1 | 3 | 2 |
| 3 | 4 | 2 | 3 |
| 4 | 3 | 7 | |
| 5 | 2 | 1 | 1 |

### Class of 1880.

| Standing on admission. | Subsequent standing. | |
|---|---|---|
| 1876. | 1877. | 1878. |
| 1 | 2 | 1 |
| 2 | 11 | 8 |
| 3 | 13 | 14 |
| 4 | 6 | 6 |
| 5 | Failed. | |

### Class of 1881.

| Standing on admission. | Subsequent standing. |
|---|---|
| 1877. | 1878. |
| 1 | 7 |
| 2 | 10 |
| 3 | Failed. |
| 4 | 20 |
| 5 | 11 |

In this last class admitted by competitive examination among 69, there is no star number; among the cadet midshipmen of the same class there are three stars, although the disparity of years is greater than usual; engineers 19.0, midshipmen 16.8. It is true the class of the latter is much larger, numbering on admission 120; but it is to be remembered that the class of engineers represent, if the competitive examination is good for any thing, which I doubt, the best 25 in 69.

Finally, time permitted me to make only one more comparison, with ref-

erence only to this last class of cadet engineers. I give below the standing on admission of those who stood first five after a year of Academical training.

CLASS OF 1881.

| Standing at the end of 1st year. 1878. | Passed on admission. 1877. |
| --- | --- |
| 1 | 8 |
| 2 | 13 |
| 3 | 19 |
| 4 | a turn back from previous year. |
| 5 | 22 |

It seems likely that some of the best men of the 69 were actually rejected by the competitive examination.

I do not, however, argue that a competitive examination is a worse system than mere favor, for admission to a naval career. I contend merely that it is no better, and I think the above figures, though limited in extent from the nature of the case, go strongly to support the *a priori* probability that competitive examination for admission to a course of naval training will not get better men than chance does.

But if so why not acquiesce in the examination, the more so because, as the essayist says, the *chance* of obtaining an appointment is thereby extended largely and embraces many who would have no claim on political favor? If I have no answer to this I must lose my case, but I think I have a good one. Although examination determines nothing of value, not even brain capacity, yet there *are* qualities, recognizable in boyhood, from which one can safely infer success as a naval officer. Courage, enterprise, leadership among comrades, perseverance, staying power, such moral qualities joined with bodily vigor, give the assured promise of the good officer. Such a standard I would hold up, as far as possible, before those in whose hands the appointments lie, hoping that in time a sound public opinion would be formed. Meanwhile I would not tie the hands of any, who should wish to exercise their power judiciously, by forcing them to adopt a system which will give no better results than simple favor.

After all, there is about competitive examination, as about many other good things, a great deal of cant. To choose a grown man to be ready instanter for some special work a competitive examination is probably very well; but it does not follow that it is equally, or at all, useful in selecting lads to begin their education for the sea.

I must touch hastily and slightly upon the other points in which I differ from the esssayist.

A course of five years appears to me too long. The only circumstances under which it could recommend itself to my judgment would be when accompanied by a reduction of the maximum age for admission from eighteen to sixteen years, or even to fifteen. A yet better provision perhaps would be that none should graduate over twenty one. Under the proposed plan some midshipmen would leave the Academy for a steerage at twenty-three and would only be eligible for the lowest commission at twenty-five.

Many of the studies proposed, however suitable for a corps d'élite, are unduly difficult and will be practically useless to the ordinary sea officer.

Notwithstanding the high authorities quoted I do not fully agree with the plan of detailing line officers in turn for staff duties. It may be well for the army, I don't think well of it for the Navy. I should rather advocate fitting every officer for deck and engine room work; to this let individuals add, and stick to, some one specialty; one a paymaster, another a marine officer, &c., until they reach the position of executive officer and captain.

The proposition of the essayist for dealing with the present grade of Passed Assistant Engineers appears to me wholly impracticable and unjust. Granting that these gentlemen could pass a satisfactory examination of the kind suggested, it is not fair to ask it of them, still less to require

them, at the age they have now attained, to enter upon wholly novel duties. I have already stated emphatically my accord with the essayist's general plan; modified in detail I should like to see it go into instant operation. But its fruits are for that future in which our contemporaries will be on the retired list. The present organization must go on until the gradual passing away of its members. one by one, shall leave the ground clear for the new; as the first set of teeth make way for the second.

My last objection is to a suggestion which I regret that the essayist should have introduced as it is not germane to the matter in hand. I do not think it conducive to discipline that the commanding officer should mess with the others. During a pretty long experience as first lieutenant, I have always found the hardest duty to be done was by messmates. A commanding officer, too, has at times to act in a judicial capacity for which he is not likely to be made more fit, by being brought into close original contact with the matters in dispute. I am sorry, as I said, that the essayist should have introduced the suggestion; for in stating my objection I have been obliged to touch, however remotely, our line and staff trouble, any allusion to which, beyond a hope that the plan of the essayist may remedy it, is wholly out of place in the meetings of this Institute.

Passed Asst. Eng. MANNING. I would like to ask Mr. BROWN if it would not be a more logical method of combining the corps to examine the Lieutenants for Passed Asst. Engineers, as it certainly is not contemplated to detail any of the present Engineers for duties now performed by the Lieutenants, but to detail Lieutenants to do the duties of Engineers.

Lieut.-Comdr. BROWN. I did not propose that lieutenants should be eligible to compete for promotion to the higher grades of the Engineer corps until they had qualified, for I say in the essay that all the courses mentioned should be thrown open to line officers, and that "the detailed portion of the corps should be line officers who had specially qualified." While on this point I would refer to what has been said as to the stoppage of promotion of Passed Assistant Engineers. I think my idea has been mistaken, for *all* of them would have a chance to *compete* for a vacancy in the next grade so that the best men among them would be promoted, without regard to seniority; and some of them do not stand any very great chance of promotion now owing to their age, so that to a certain extent the prospects of the best men would be improved. As we are on the question of the engineer corps now, I would like to say that I do not think the essay implies that there shall be a shifting from deck to fire room of the firemen as was stated a few moments ago; but that the firemen shall be seamen first, graduates of the apprentice ships. With regard to the matter of the pay of these men, they receive when on board sea-going vessels the pay of their grade whether steaming or not. They have been considered as occupying the position of petty officers on board ship; and as the other petty officers receive only seaman's pay when on board the receiving ships, I think it no more than fair that the firemen, who are doing none of the duty of their rates, should receive the same amount.

Passed Assistant Engineer MANNING. I would like to ask Commander MAHAN if the relative percentage of graduates under the two systems sustains his position?

Commander MAHAN. There are not enough statistics to determine that question: I have taken as a standard 3, which means "good" not considering anything below that as indicating more than that *tolerable* degree of proficiency which permits a man to pass. I think that a complimentary 2.5 is not seldom given, as there is certainly no desire to bilge anybody if it can be avoided.

Commander GREENE. It must be remembered that of the classes spoken of but one has graduated, so that no fair comparison can yet be made with regard to the percentage of graduations to entries.

Passed Asst. Eng. MANNING. As to the circumstances under which a "2.5" is given, they are as likely to occur with those who have en-

tered under the standard examination as under the competitive, and if Commander Mahan will examine the records, I think he will find that of those who enter by the standard only about thirty-three per cent. graduate and of those who enter by the competitive system about ninety per cent. graduate, and that with a much more difficult course during the last year. I do not believe we always get the best twenty-five of those who compete, but that we come nearer to it than by any other method,

As to Mr. BROWN's project of recruiting the Line, Pay, Marine and Engineer Corps from one common source, no one would object; and I, for one, think it an excellent plan; but they must be separated much earlier into their respective corps than Mr. BROWN proposes; either at the end of the two years preparatory course or at latest on their promotion to the grade of Ensign.

From those who choose Engineering should be selected the best for Constructors and designing Engineers but not till they had made at least one three years' cruise at sea as watch engineers, for no man is fit to design a vessel or her machinery till he has been to sea long enough to know what is needed; for we have all had too much experience with vessels designed by men whe have never been to sea.

Mr. BROWN, a few minutes since intimated that his plan improved the prospects of the Passed Assistant Engineers for promotion and that as it is now, many of them reach sixty-two years of age before there is a vacancy for them as Chief Engineers This is rather a dark view of the prospects, but it must be admitted they are not particularly bright, as for instance there will be by the regular order of things, a vacancy for me as a Chief Engineer in twenty years lacking a few months; but dark as is the prospect, most of us older men would prefer taking our chances where we are than to join another corps at the foot of a list part of whom we have assisted to educate at the Academy.

And how would the country benefit by this mixture of shot and peas, and then sorting out the peas again? Certainly you cannot make shot of peas or peas of shot by any such method; the best that might be expected from any such mixing and sorting is that a few of the most incompetent Engineers might be replaced by some of the best Lieutenants of the line who are of more value to the country and the service where they are.

I would instead make the education of line officers in practical engineering much more thorough than it is, as any one who is to command a steam ship should know all about her. The junior line officers at sea should stand engine and fire room watches, not as has been the custom in the service merely as lookers on, but with responsible duties.

Mr. BROWN and Mr. GOODRICH both recommend giving Machinists warrants, which I think would be a grave mistake. Increase their comforts as much as possible, give them quarters such as now occupied by the forward officers (who with the exception of Boatswain could well be dispensed with on our Third & Fourth Rates) but do not make officers of them, for then you destroy their usefulness as skilled mechanics and defeat the very object for which they were created. Make their appointments continuous by giving them a share of shore duty at Navy Yards, caring for and repairing vessels in ordinary. Giving them warrants would be but commencing the Engineer corps over again; for in the first Naval steamers the Assistant Engineers were what Machinists would be if warranted.and with this recommencement of the Engineer Corps would begin again all their discontent; for we have been told that the Engineer Corps is eminently a discontented one, and I acknowledge that it has always been so; and this very discontent, with the help of rigid examinations, has been its salvation. It has never folded its hands with the comfortable assurance that it knew all worth knowing, but has ever striven for professional advancement. Why repeat this evolution when the corps can be better recruited in other ways?

I remember soon after entering the service, hearing an old Commodore say, that "if you compared the average Naval Academy graduate with a

newly appointed 3d Assistant Engineer the Midshipman would know the more of the two, but five years later this would be reversed, in a large majority of cases."

This has been remedied of late years by the adoption of examinations for promotion in the line and I think Mr. Brown should add to his scheme of education, as an important item, rigid examinations in all corps, at least to the grade of Commander.

As to Mr. Brown's project for firemen he must remember that the handling of fire tools is but a part of their duties, that it is when fires are hauled that some of the most important duties of the firemen commence. If such of the Apprentices as evince mechanical tastes could spend two or three years as laborers in the Navy Yard Machine shops they would then make excellent recruits for the fire room.

Master Clason. I should like to say a few words in reference to the assimilation of those Naval Constructors now in the service, and the education of those who are to replace them, as proposed by Lieut. Comdr. Brown.

In reference to those officers now in the service, it is proposed that, 1st. "No more appointments to the grade of Assistant Naval Constructor should be made, and no promotion to the grade of Naval Constructor." That no more appointments should be made to Assistant Naval Constructor is, I think, a step in the right direction: to stop the promotion of those occupying that position (5 only) seems unnecessary and unfair. 2ndly. "Competent Chief Engineers should be allowed to enter upon the duties of Constructors, and inducements offered to the present Constructors to retire."

The question naturally arises; *can* any Chief Engineer, or *any* one, not epecially trained for the purpose, be competent to take the place of a Constructor, or can he easily acquire the necessary knowledge and skill?—I think not!

At the Naval Academy we teach the Cadet Midshipmen to handle the marlinspike, the oar and the sail; the Cadet Engineer to handle the hammer, the lathe and the engine; but where is the Naval Constructor taught to handle the saw, the adze, the auger? And yet such teaching he must have. Where are our Chief Engineers to get it; and are there sufficient inducements offered them to acquire such knowledge? The Naval Constructor must, in the words of Boyd, learn "by practice; he needs certain qualities of head, eye, character and constitution *not easily nor quickly acquired*; but, therefore proportionately valuable."

I think it better, therefore, not to interfere with the Naval Constructors now on the list, but to stop all further appointments and immediately prepare new material to fill any and all vacancies.

As to how this new material *might* be prepared, I am not competent to give more than a rough sketch, but I propose;

1st. An Academic Course, either as it is, or as proposed by Lieut. Commander Brown. A two years cruise, after graduation, as proposed by the same gentleman.

2ndly. Take, then, such as desire to pursue this course, either from the service at large, or from the newly commissioned Ensigns, and let them be taught at a Navy Yard, where Construction is actually going on and where there are more opportunities for observation than at Annapolis or Newport, and where the expense of establishing such a school would also be less. The courses to be three, or more, years as might be necessary to gain a complete practical and theoretical knowledge of the subject, to be followed by a searching examination, those failing to be returned to the service, where their knowledge would alway be of some use, those passing successfully, to take one cruise; then to be detailed to the various yards, as needed; while serving on such detail to have an increase of 10 per cent added to their pay; on a vacancy occurring in the higher grades, the position to be filled by senority, or by competitive examination, as might be judged best for the interests of the service.

Master STAUNTON. I rise with considerable hesitation and diffidence to give my views on this essay especially as they involve an unfavorable criticism of some parts of it, and as the weight of expressed opinion here this evening has been against the opinions that I am about to advance. But no topic of greater importance can come before the Institute for discussion than the topic of this essay: and if the voice of the Institute is to have any weight in the future decision of this question, the discussion should be free and ample, and any opinion, however diffidently expressed, may be placed upon record and judged by its merits.

Lt.-Commander BROWN has taken for his motto "who does not progress, goes backward," but it seems to me that in his plan of naval education and reorganization, he has denied the accepted application of his own motto in all other learned and scientific professions. Instead of limiting individual application, he extends it. Instead of directing individual effort to advancement in specialties, he spreads it over a still wider field. In other professions it is thought that progress lies in a different direction. Lawyers devote themselves, some to real estate practice, others to the practice of commercial law, still others to different branches of jurisprudence; and they attain celebrity in their special departments at the expense of their knowledge of others. The best medical men are specialists. A country physician may set a broken leg or doctor a diseased eye; but if the fracture is a bad one, or loss of sight be threatened, we apply to the city expert.

It may be said, and I confess the accuracy of the statement, that the Naval profession differs from those civil professions to which I have referred. It does differ in a marked degree; but not to the extent of denying the application of this general principle. A man can certainly learn both ordnance and mechanical engineering; but he is not as likely to become an expert in either as if he applied himself exclusively to one. It is not the question of time so much as that of diverted attention and interest. Success demands concentration.

The profession of the line officer as it stands to-day is so comprehensive that the most ambitious and best minds of the service devote themselves to special branches of it. Should its sphere be enlarged this tendency will be increased.

Should an attempt be made to check this tendency by an arbitrary detail for duty with no regard for individual tastes or individual preparation in special branches, the result would be discontent and hopeless mediocrity, or worse than mediocrity. If the contrary system should be pursued, and men who have qualified themselves in special branches be selected for duty in those branches, the tendency is marked and encouraged, and thus we drift back into corps in effect if not in name.

I understand that Lt. Comdr. BROWN desires to encourage this attention to specialties: and he proposes to supply the vacancies in the "permanent" part of the staff corps by appointment, subject to competitive examination, from those who have served two details at sea on that special service. This offers to my mind a serious objection. These "permanent" positions will be desirable and much sought after; the greater part of those who apply must fail of their object, no matter what their merit, and then they are relegated back to their executive duties after having devoted six, eight, or ten years to special study, which in the ordinary line of their duties is of small advantage to them, and may be regarded almost as so much time wasted.

That these views make the organization of the service more complex I freely admit; but I hold that increased complexity is a necessary accompaniment of *progressive* naval and military organization; either increased complexity or its opposite, diminished efficiency. Nor need this greater complexity diminish in any sense the value of a service. Every officer trained to certain duties, and fulfilling perfectly the object of his training, is a most valuable part of the whole. Of course greater ability is demand-

ed of the general or admiral who controls such an army or navy. I have no doubt that the successful commander-in-chief of to-day is a man of greater genius than he who was successful in the time of Alexander—or even in the time of Napoleon.

The line officer of our navy has now his executive duties to look after, besides keeping himself ready for service as a navigator, surveyor, and ordnance officer. It is quite as much as he can do well. And it must be considered in this connection, that if our Navy is to endure, ordnance will mean something more in the future than it has in the past. The *esprit de corps* of the service will demand more external support than has been given it of late years. The *personnel* has done what it could; but we don't take the pride in our flag that we should feel if it floated over ships and guns that compared better with those of other naval powers. With improved ships and ordnance will come incentive for study of those matters, and greater demand for it.

I fail to see the force of the arguments adduced by the essayist from other services. The English are abolishing their navigation officers as a separate corps, it is true, but their ordnance officers are still part (in the grade of lieutenant), and if there has ever been any proposition to incorporate executive officers and engineers, I have never heard of it.

The staff of an army includes much more, if I have a correct idea of army organization, than the *staff corps* of a navy; and staff duties include many that our line officers now do. All duties of organization, many details of procuring and transporting stores, everything relating to ordnance and equipment, surveys, and the making of charts and plans of operations, are in the hands of the line; and whether as army staff, or as naval line duties, they are necessary items in the experience of every officer who is to command.

I can well understand the value which military men place upon this varied experience, and therefore their recommendation that line officers be detailed for a term of staff service, at the expiration of which they shall return to their regiments; but an infantry or cavalry lieutenant detailed to serve as an ordnance officer or quartermaster does duty not far different from that to which naval line officers are constantly liable. Here I would like to ask Lt. Comdr. BROWN if in any military service, the engineers are detailed from the line.

Lt. Comdr. BROWN. In India, according to Upton, many of the public works are in charge of officers who are detailed from the artillery, and from what is known as the *staff corps*, (to which all of the European officers of the Indian army will ultimately belong and to enter which *all* officers above the grade of sub-lieutenant are eligible).

Master STAUNTON. I did not know that there was any exception to the rule.

As to the appointment of paymasters and marine officers, I think with Lt.-Comdr. BROWN that they should be selected from graduates of the naval academy; but I would like to see their appointments permanent from their entrance into the corps for reasons already given.

I shall conclude my remarks with a reference to the "ideal naval officer" whose acquirements are enumerated in the pages of the essay.

Many lines are filled with the mere list of these accomplishments, some of which might be in themselves separate professions. It would be very fine if this ideal could be realized in one individual, but I do not think it possible. Probably it may be deemed better to attempt less and to do that less more thoroughly; for it is to be remembered that a struggle for an impossible ideal may result in the worst failure.

Lieut. SOLEY. It seems to me that the plan of amalgamation proposed would be unjust to the officers who would be most affected by it and to those who are coming up to take their places. Such a plan could only be put in operation in the future. Those who are now in the service have reached their positions under a certain understanding with the government,

so to speak, and if it were advisable, which I doubt, it would certainly be unfair. I think that the essayist proposes to devote too much time to preliminary teaching at the Naval Academy; the result would be that we should really have to teach more than is now done and would require a much larger corps of instructors and a larger establishment. I think that the desired end may be better attained by raising the standard of admission, first giving warning to the schools throughout the country. The different parts of the country are sufficiently on a par in respect to education and there would be no unfairness in so doing. We could then give in four years the instruction which we now seek to give in three, and with it more thorough practical instruction. The essayist says that it is not midshipman alone that we wish to train but the commanders of the navy of the future. If that is the case we must devote much time to theoretical instruction compared with the practical, for it would be ruinous to depend upon practice without a scientific basis of knowledge. But it should not be the commanders of the future whom we seek to train at the naval school. In all other branches of study the University course is preliminary and never final. At its close the student goes to the law school, scientific school, &c. to complete his education. If we could say that it *is* the midshipman alone or rather the junior officer whom we seek to train at the naval school we should make a stride in advance—for we would then only attempt to lay the groundwork for a scientific education and could prepare him thoroughly to perform the duties of a subordinate officer. I endorse heartily the proposition for an officer's course, and I hold that when a naval college for officers is established we shall have found the place to educate the commanders of the future. I agree with the remarks of Comdr. MAHAN that all officers cannot be expected to go in for special studies and that it is not necessary, but I think that the four cardinal points of an officer's education, gunnery, seamanship, navigation and steam should there be taught so that every officer should possess a thorough general knowledge of these subjects. I must disagree with a point advanced by the Essayist that every officer should go through a course in torpedoes, but that the course in ordnance should be optional. I think a thorough course in ordnance should be obligatory and consider it far more important than that in torpedoes. The navy is of little use if it cannot fight: guns are given us to fight with, ships to carry the guns, machinery to work the guns. The proper use of every weapon which he may have to fight with is of the first importance to a fighting man and next comes a knowledge of the powers of the weapons of his enemy.

With regard to the naval constructors I think the plan proposed is a rather violent one. Up to 1850 our naval constructors were ahead of the whole world and it is hardly their fault that they are so much behindhand now. In the first place they never go to sea at all and I do not see how they can understand all the needs of a ship unless they have been to sea at some time of their lives. Again they have few opportunities for seeing what modern men-of-war are, for foreign squadrons rarely visit our own coasts and the naval constructors never go abroad. It is for these reasons that the models and internal arrangements of our men-of-war remain as they were many years ago. A great many plans have been suggested for raising the standard of professional attainments in that corps but I do not think they are necessary. The present law provides for the education as naval constructors of such cadet midshipmen or engineers as may be recommended by the Academic Board at the Naval Academy, and I venture to say that no one would be recommended by them who was not thoroughly capable.

In the essay very little is said about the education of the men, and in the discussion we have drifted still more. Important as is the question of an officers's education, the bone and sinew of the service must not be neglected. Some thing has been said about our training ships. Undoubtedly they are doing a good work but if we depend entirely upon them to sup-

ply the wants of the service we may suddenly realize that our navy is manned by boys. But the boys are now the smallest part of the enlisted men. The seven thousand men who are now in the service form the strong partof the crews and it is for their education that I speak; no one will say that they do not need any teaching—on the contrary I am certain that they need a great deal. This is not the time to suggest a scheme for their teaching, but no other service neglects it. In the English navy the men are trained to be gunners and thoroughly trained. In the French service the system of education for the men of the fleet is as thorough as every thing else in that service. The boys are taken at an early age, and carried through every stage. Not only that. On board of every cruiser the men are taught and the system is so thorough that the same books of study even are used throughout the navy. In the Italian service the conscripts are taken on board of a gunnery ship where they find one gun of every class used in the service with its carriage, projectiles, etc.; after three or four months of constant drill they are sent to the cruising ships and at the expiration of a cruise the best men are picked out and returned to the gunnery ship for a more extended course of training. I have cited these cases to show how important the subject is considered in other services, and in the earnest hope that more will be done in our own.

Rear Admiral John Rodgers, (The President.) I think it a duty, but by no means a pleasant one, to say that having read the Prize Essay of the Institute, I dissent from many of the views there set forth. Few men excel in more than one profession: jacks-of-all-trades are proverbially supreme at none, and each branch of the Navy is too wide in its scope for the same man to be excellent in each.

Lieut. Collins In the essay a radical reorganization of the navy is proposed by its writer, who expresses his belief that it will "bring harmony to the service and add more to its efficiency than any other system that could be pursued."

After giving these important subjects such consideration as has been possible in the very short time allowed since the receipt of the Essay, I am of the opinion that some of the changes proposed will militate seriously against the efficiency of the service, As for *harmony*, that is greatly to be desired; but too much should not be sacrificed in an attempt to secure it, for, it should be remembered that a *harmonious* organization is not *of necessity* an *efficient* one.

In any scheme for naval education the aim should be to produce the most efficient officers for the various duties to be performed. The officers provided, the organization of the service should be such as best to direct their efforts to the production of an efficient whole.

Harmony will come to the service only with the creation of such an *esprit de corps* as will make every member feel that the good of the whole is the one object for which he should strive.

The essayist proposes that, with the exception of the surgeon, all officers of the navy shall be of one corps; serving in rotation as line officers, engineers, paymasters, and marine officers. The result of this will be, in my opinion, to make our officers "Jacks of all trades and good at none."

There is a limit to the versatility of the average mind. We have already united in the line officer the seaman, the navigator, the ordnance officer, the marine artillerist and the soldier. To prepare himself to make even a respectable figure in these several specialties is a task quite equal to the abilities of the ordinary man.

As regards marine officers and paymasters, I see no objection to the plan proposed. The duties of the former would require no additional knowledge on the part of the line officer, and those of the latter would be readily learned and (if proper means were taken to provide efficient clerks) would not be so engrossing as to prevent the officers detailed to perform them from standing his watch also, as would the one detailed to command the marines.

These changes are practicable and would result in good. But with the engineers the case is different. Engineering is a profession by itself. An officer could not be expected to stand a watch and perform the duties of an engineer at the same time. Hence if the system were inaugurated it would result either that we should have specialists in engineering who would do no other duty, or, if rotation were insisted upon, we should spoil the line officer only to make an indifferent engineer.

In any projected consolidation, therefore, the engineers must be counted out quite as much as the surgeons.

The engineer corps should be kept distinct, but it should be very much reduced in numbers (of course without injustice to any one now in it) and placed on an entirely different footing from that which it now occupies. It should be consolidated with the constructors, and its number should be sufficient to provide the necessary constructors and supervising engineers and a chief engineer for each vessel in commission, with a relief.

For the practical manipulation of the engines a corps of machinists with the rank of Warrant officers, as suggested in the essay, should be formed.

The plan proposed, for absorbing the engineers now in the service, into the Line, even if it were desirable, appears to me to be utterly impracticable. It is out of the question for the Assistant and Passed Assistant Engineers now in the service to qualify themselves for the duties of Lieutenants in two years; and to compel them to spend that time in cramming book seamanship, navigation, and gunnery *in order to pass a line officer's examination or be denied promotion as engineers* could, it appears to me, result only in their being less efficient in their own specialty without gaining any really useful, practical knowledge of any other.

Aside from details, however, the general scope of the scheme proposed in the essay is one to which I cannot assent. Beginning with the Naval Cadet in the proposed course and following him through, at what do we arrive? At a *competent commander*, either of a single ship or of a fleet? No. But at a *scientific designer of hulls and engines*! Every thing in the scheme tends towards the production of a class skilled to contrive the vessel in which to fight, while the man who is to fight her is almost ignored.

Will it be wise to instill into the mind of the future Naval Cadet the idea that such is to be the great end and aim of Naval training? I think not.

Without in any way underrating the value and importance of such a scientific corps as is proposed, I am constrained to think that the end and aim of naval education should be to produce efficient, skillful, daring *commanders*, for without them the finest productions of human skill in construction will avail us nothing.

Lieut. Comdr. Brown. I think that both Lieut. Collins and our honored President (for whose opinions I have the highest regard) have misapprehended the idea which it was my intention to convey: and it is quite likely that I have failed to be sufficiently perspicuous. I did not intend to propose that officers should serve "*in rotation* as line officers, engineers, paymasters and marine officers," nor that a watch officer should alternate from deck to engine room (although the regulations of the navy provide for such a thing even now): this would indeed make a man "every thing by turns and nothing long," and would be most fairly open to the "jack-of-all-trades" criticism to which Comdr. Mahan has already replied, in better words than I can find. Let me quote from the essay itself: "We should have the young officer fairly prepared for his future duties after a course of preliminary training lasting seven years: he would have a thoroughly good foundation upon which to build *any specialty* to which his natural disposition inclined him: and while he would not lose his identity with the Line he could avail himself of the opportunity offered to apply himself to further improvement in any direction he saw fit." Again: "The detailed portion (of the Engineer Corps) should be line officers who had *specially qualified* for it in the post-graduate courses mentioned hereafter." I meant in these sentences to con-

vey the idea that a man who was inclined toward Engineering should take that as his specialty (just as officers now take up Ordnance or Hydrography as specialties) and be given opportunities not now afforded, for a thorough education in its higher branches: and from these officers would be chosen the permanent Engineers, "uniting in their corps the offices of designing and construction of vessels as well as of the machinery to propel them," as is stated in the essay, and with which opinion Lieut. COLLINS expresses his agreement, though he does not propose any plan for obtaining these men in place of the one offered by me.

It does not seem to me that in "the requirements of the ideal Naval officer" I have lost sight of the purpose of making a "competent commander." I think that I have eliminated in those requirements all things looking to the designer of the fighting machine as being the man to command her when constructed. We must have scientific designers, and I think that a sea experience is necessary for such. In the scheme I have outlined for the education of officers, it seems to me that I have provided not only for the production of such men, but that quite scope enough is left, just as is now the case (only with a better foundation,) for the Line officer pure and simple to devote himself to as near an approach to the ideal requirements as is possible in any individual case.

If, Mr. CHAIRMAN, there is no one else who desires to make any remarks, I would request that you give to us your ideas upon the subject brought forward.

The CHAIRMAN. While I think that the main features of the plan presented in the essay might be carried out with great advantage to the service, I may be permitted to occupy your attention for a short time with one point that seems to me to call for revision. This is the proposed method of supplying the vacancies in the three permanent staff corps, and especially that of the Engineers, composed of officers above the grade of Lieutenant. These are to be filled by competitive examination from among those Line officers who have elected the special duty of Engineer, Pay, or Marine officers, and who have served two details at sea. It seems to me that such a scheme would be impracticable, or, at least, attended with great difficulties in practice. The essential difficulty lies in the irregularity with which vacancies would occur, the absence of any provision for classifying the competitors, and the uncertainty of the times of examination, of the number and gradation of the possible candidates, and of disturbing influences resulting from the requirements of the service. For example, a vacancy occurs; twenty candidates appear to compete for it, and the competitor who passes at the head of the list is promoted. A month later, a new vacancy occurs, and another examination is held; are the nineteen competitors who failed before, to be called on to pass at the new examination? If so, the officers who have passed two details at sea would spend the rest of their service in examinations, until promotion in the Line excluded them from further competition. The necessities of the service, however would prevent many of them from competing the second time, by removing them to distant points, afloat or ashore. In fact, these contingencies of the service would make it problematical who, among those eligible, could attend any given examination, or even how many competitors there would be. Even supposing that those unsuccessful at the first examination were allowed to stand upon their record at that time, in competing for a new vacancy, in the meantime new candidates would have come forward who would have to be examined, and the results of the second examination would be compared with those of the first, an obviously unfair method of competition. Unfortunately, there seems to be no way in which any limits could be fixed, as to time, or number of candidates. The competition is open to a body of men, ever varying in number and composition, and so detailed for duty in the service as to make it a matter of chance who could, and who could not, come forward, at any given time. There

might be one candidate, or there might be thirty. Such a scheme must inevitably have some elements of unfairness as well as confusion.

Another and more vital objection to the proposed organization, relates especially to the Permanent Engineer Corps. This corps is, in the words of the Essay, "to be the *corps d'élite*. The scientific men of the service should there find their appropriate place. They should be, also, the Constructors, uniting in their corps the offices of designing and construction of vessels as well as the machinery to propel them." Now, I agree with the writer that this is a most important corps to have in the Navy; but are the means provided by the essay calculated to bring about the end? Have the officers who are to form this *corps d'élite* any opportunities for qualifying themselves beyond their fellows? They are selected, it is true, by competition; but their education is precisely similar to that of all other officers detailed as Engineers. It consists of five years at the Academy before graduation, and two years of a post-graduate course, after service at sea, with perhaps a shorter course in steam at Newport.

The profession of a designer and constructor of ships and engines, is a special, absorbing, and extensive one—or perhaps it might more properly be said to include two professions,—and it requires a special, absorbing, and extensive education, quite distinct from that required to make a good Engineer in the ships of the fleet. The general education, therefore, proposed in the plan, is either far in advance of the requirements of Engineer officers in general, or it falls short of what is *necessary* to make an accomplished constructor.

Again, it is extremely desirable, if the Navy is to get the full benefit of the services of its Constructors, that they should enter upon their profession early in life. The proposed plan makes this impossible, by requiring, as a condition, a service of two details at sea, presumably of three years each; which would make eight years, including the intermediate shore service. Supposing that the officer enters the Academy at sixteen, the average age of admission, he graduates at twenty-one. He then has two years of sea-service as a Midshipman, a year more or less at the torpedo school, two years as a watch officer, and two years in the post-graduate course in steam. This, combined with his subsequent service in the engineer detail, would make fifteen years of service after graduation; so that under the most favorable circumstances, he could not enter into the competition for the permanent corps, before the age of thirty-six; and in many cases he would be several years older. The élite corps of Constructors would thus be composed of men, selected at the age of about forty, whose education had been in no way different from that of the Engineer-Line-officers in the service, and who could not know until after the competitive examination, that the remainder of their life was to be devoted to this special profession; while the government would lose their services as professional Constructors during the most efficient years of their life.

There is a third point to which I should like to call attention, the duties assigned to the members of this Permanent Engineer or Construction corps. I see with some surprise that they are to be sent to sea as Fleet Engineers, in the lowest grade, for three years, at least, I suppose,—and also to make a three years' cruise in the next higher grade. I should like to ask Lieutenant-Commander BROWN why it is proposed that these officers, whose duties are to be those of designing, construction, and the supervision of repairs, shall go to sea for six years.

Lt.-Comdr. BROWN. That they may by familiarity with the working of a ship and her engine at sea be the better prepared for their duty as Constructors. In this opinion I think I am supported by the majority of the service.

The CHAIRMAN. But how much sea service is necessary to give them this familiarity?

Lt.-Comdr. BROWN. I should not like to set any limit to it; their service

should be such as to keep them familiar with the sea-going qualities of their constructions.

The Chairman. I quite agree with Lieut.-Commander Brown that they should have some experience in a sea-going man-of-war; but with all deference to the opinion of professional men, who are far better qualified to judge than I am, I submit that there is some limit to the amount of sea-service necessary for this end. The officers in question have already had four years afloat as Midshipmen and watch officers, and two details, or six years, as Engineer officers; making ten years of sea-service, besides practice cruises, before they compete for the permanent corps. After the competition, they are to spend six years more afloat. If this is the case, where can they study their profession? They certainly cannot do so at sea.

Lt.-Comdr. Brown. I must say that I cannot agree with the opinion expressed. I think that a great deal of studying may be done at sea.

The Chairman. I had always supposed that the conditions of life afloat were unfavorable for study, whether at sea or in port; particularly for close special study by an officer performing his regular part in the routine of ship duties. No doubt much general reading may be done at sea, and much general information gained; but this is not the kind of study that is needed. It will not take the place of thorough technical training under competent instructors. And if this is true of the period before the profession is actually taken up, it applies much more strongly to the later period.

As to the benefit that is derived from sending Constructors to sea, I confess that my opinions are of no value in the matter: but I should think that ten years passed afloat would be enough to give the necessary familiarity with the working and behavior of ships at sea, and that any further time that could be spared from actual duties would be better spent in repair shops. If I am not mistaken, the French Constructors, or Ingénieurs, as they are called, only go to sea for six months in the squadron of evolutions. The English constructors are not naval officers at all, but civil officers; and though there is a provision in their regulations that they may be sent to sea for a year after their course of instruction is finished, it is rarely or never carried out.

I think that a simple remedy for the difficulties I have endeavored to point out in the plan, might be found in a slight modification of certain details. It is proposed in the essay that all officers who elect the Engineer detail should pursue a course of two years in steam and naval architecture at the Naval Academy, after their term of service as watch officers. I should think that one year in this course would be enough to make competent Engineer officers; for it must be remembered, that this is in addition to the five years' course at the Academy, whose graduates are to have the same standard of proficiency that Cadet-Engineers now attain. At the end of this year of post-graduate instruction, the officers will pass out in the Engineer-detail, and perform the duties of Engineer officers in the fleet. Let the best man in each year, however,—or the two best, or three best men, as the service may require,—be reserved for a further course as students of Naval Architecture and Engine construction. If it is desirable to have specialists in each branch, let the officer who passes at the head of the list. in each year, elect which of the two branches he will follow; and let number two take the other. Their advanced course of two years should include the highest mathematics and applied mechanics, and work in the physical and chemical laboratories, in addition to the fullest possible course in the strictly professional subjects. The summers should be spent at the Navy Yards, or anywhere where they can best get practical instruction; and even then they would get far too little. At the end of the three years of post-graduate instruction, let them be promoted at once into the permanent corps of Constructors or Constructing Engineers, where their duties should be those of Constructors, Designing Engineers, and Draughtsmen, at the Department and at the Yards; but not for any service afloat; for they would already have had four years at sea. It seems to me that such a plan would present many

advantages. The Constructors would take up their profession at the age of twenty-eight instead of at forty. They would have received, at least, a high theoretical education for their profession, and some means might be devised for supplying their practical wants. They would be selected by competition as truly as under the other plan, but it would be a competition with well-defined limits and conditions. From the mode of selection, they would be eminently worthy of admission to the *corps d'élite* of the Navy; and they would get a tangible and prompt reward in the promotion that followed their efforts.

A system in many respects similar is now pursued with the best results, in the English service, though, of course, there is no amalgamation of the Staff Corps with the Line. Constructors and Designing Engineers are selected respectively from two classes of students, shipwright apprentices, and Engineer Students; and from the latter are recruited also all the Engineer officers. Both classes of students are originally selected by open competition, and both begin their training in the dockyards, receiving practical instruction in the shops, and a good course in mathematics at the dockyard schools. At the end of five years, three of the shipwright apprentices are selected by competitive examination, to be educated for Naval Architects. The successful competitors are sent to Greenwich, where they pass through a three years' course of the highest character; and at its close they receive immediate employment as Constructors or Draughtsmen, at the Admiralty or in the Dockyards. The Engineer Students, after six years in the yards, are all sent to Greenwich for a single year, at the end of which, two of them are selected by competitive examination, to be educated for Designing and Constructing Engineers. The rest pass into the Engineer corps of the Navy, and are sent immediately to sea as Assistant Engineers. The additional course for the successful competitors is two years, and at its close they enter upon duties similar to those of the construction students, but in their own special field. In all courses not strictly professional, the students of naval architecture and marine engineering are united, the number of students being always five in each of the last two years: but in the studies directly pertaining to their profession, they receive separate instruction. Their instructors are officials, attached to the construction department of the Admiralty, and are men of the highest professional attainments; the problems given them in ship and engine design are questions of the day, upon which the Constructors of the Navy are at work at the moment; and the work that they perform as students not only contains much that they will actually use in their future career, but often gives valuable suggestions to their instructors.

Such a plan as this, which must certainly give competent Constructors, provided always that the needful workshop experience is given them, seems to be susceptible of application either to the Navy as it exists, or to such a reorganized Navy as that which the essay proposes.

Lieut.-Comdr. Brown. I will endeavor to reply as concisely as I can to some of the points raised by the gentlemen who have preceded me, for I can not hope to reply fully or satisfactorily, to the objections which have been so ably urged against some of the details of the essay; I am glad to observe that, as a rule, those who have spoken are in favor of the principles which I have advanced: as to details we cannot expect unanimity of opinion.

With regard to the Pay Corps it does not seem to me to be a matter of great difficulty to carry out the ideas I have advanced. I neglected to state in the essay that the article quoted from the "Army and Navy Gazette" was written by a Paymaster. In further support of my position, I quote as follows from the same paper of the date of March 1, 1879; this letter is also written by a member of the Pay corps.

"I am quite of the opinion of one of your correspondents that paymasters, as a special class, should be abolished and combatant officers employed instead. Sub-lieutenants and lieutenants should be invited to qualify for

paymaster's duties; a school of instruction could be established, and after a course, say of six months, the officers under instruction should be examined: if found fit, they would become eligible for appointment as sub-lieutenants or lieutenants, for paymaster's duties. It should be distinctly laid down that the fact of officers being qualified for paymasters' duties should not interfere with their prospects of promotion, and the same officer should never be employed successively for two commissions as lieutenant for paymaster's duties except at his own request, and even then, before being so employed, he should be obliged to go through a short course of gunnery. By the above means the Navy would have trained officers doing paymasters' duties who would be able, should occasion require, to take military command. * * * * * * * * *

A very large number of the paymasters, assistant paymasters, &c., at present on the list, would to my own knowledge, be very pleased to quit the service if they were permitted to do so and a liberal retirement scheme issued. Of the remainder, those under thirty that desired it should be allowed to qualify in seamanship, gunnery and navigation, and transferred to the lieutenant's list, and those that do not wish so to pass should be still employed as paymasters till the class died out. Such is a rough draft of my scheme. It is, in my humble opinion, the only way there is of taking a step in the direction, and one that is so much now needed, viz.: to provide combatant for non-combatant officers."

In an editorial article in the same paper, I find it stated that "the amalgamation of the paymaster's branch with the executive has often been advocated in these columns." I would like here to call attention to the fact that by *executive* in this connection is meant the branch known to us as the *line*: I do this because I have heard it stated that my idea was to place upon the shoulders of the executive officer in our service the additional duties of paymaster; nothing was certainly farther from my intention. I deem it a matter of importance and directly in the line of his duty, that a commanding officer should understand the subject of the accounts of his ship's company; and the time spent by the lieutenant detailed for this duty would be preparing him in this regard directly for the command which he hopes to have in the future: certainly as much as his serving a term as an instructor at the Naval Academy, in (let us say) the department of English studies or modern languages. Besides, I do not intend that he shall make two successive cruises as paymaster.

For several years it has been the habit of the Paymaster General in his annual report to recommend that appointments to the Pay corps should be from the graduates of the Naval Academy; and it is, after all, it seems to me, merely a question of methods. My object is to enhance the fighting power of the *personnel* of a vessel. In my own knowledge there is an instance of at least one commanding officer's performing the duties of paymaster of his vessel (in the coast survey) for over three years, to the satisfaction of the Treasury and Navy Departments. Our Light House Inspectors are charged with the disbursement of tolerably large sums of money and have always, so far as I know, given entire satisfaction. And I am informed by reliable authority that the Secretary of the Treasury has recommended that still more money be placed under their control, in order that they may pay the light keepers, in addition to the other payments with which they are at present charged. The Engineer Corps of the Army also disburse large sums of money, and have given entire satisfaction so far as I know. None of those officers to whom I have alluded as disbursing the public money are obliged to give bonds. [Indeed, if I am correctly informed, the giving of bonds by the pay corps of the English navy has been dispensed with.] In view of all these facts there would seem to be no valid reason why the same class of men who handle money in the service of the Light House Board, should not do the same on board of vessels of war.

So far as regards the *entire* duty of the pay corps being done by the line,

I am inclined to think that the scheme which I have presented is preferable, for the reason that it is better to have permanent officers to fill the positions to which it was my intention they should be assigned: namely, those of purchasing and disbursing officers, inspectors of provisions and clothing, and paymasters at Navy Yards, Naval Academy and Naval Asylum. All ship duty (including receiving ship and storekeeper duty) could readily be performed by detailed lieutenants; and if it ever became necessary to have additional officers for temporary pay duty on shore they could easily be supplied from the lieutenant's list.

As I have stated in the essay, I have not attempted to elaborate any scheme for the post-graduate course to be pursued by the officers who select the engineering branch. As to the objection that in order to be a successful engineer or a successful anything a man must be a specialist, I reply that practically in the navy we do not find such men; that is, men who devote their entire time to one particular branch of their profession. That the education which is now received at the Naval Academy is deemed sufficient to qualify the present Engineer Corps for the performance of their duties, is I think sufficiently shown by the graduated cadet engineers. I have never heard that these young gentlemen are not competent to perform their duties, and the fact that a number of them (who passed through only a two years' course) have been promoted to assistant engineers within less than four years from their entry at Annapolis, would seem to bear me out in this assertion. As by my plan all the midshipmen would have the same education as that given cadet engineers now, I think that the result would be that we should have a comparatively large number of officers who could be detailed for engineer's duty on board ship, while the permanent engineer corps would be recruited from men who had passed high in the courses in Naval Architecture etc., and who would, with the best men of the present corps, be practically the only ones who could compete for these permanent places. The competitive examination for a commission would of course result in but one man's obtaining the prize; should another vacancy render a second competition necessary, those men who had formerly appeared could either appear again or could stand upon the record made by them at their first examination. This is practically done in the examination of Assistant Surgeons and Engineers whose relative positions are not assigned until all the date have been examined, and these examinations often extend over many months. It does not seem to me that the time devoted by a Line officer to Engineering will be any less hindrance to his efficiency, than a similar amount of time devoted to Ordnance.

If I understand the idea advanced by the Chairman (and I am very sure that all will admit that the peculiar advantages which he has enjoyed for a study of the subject of the essay entitle his opinion to very great weight), the Engineer corps for duty as such *at sea* would be practically abolished, and its duties relegated to detailed officers of the line; while the duties of designing and construction would be performed by the permanent men, who no longer went to sea; this would of course necessitate a lessening of the number proposed for the corps. While I think that the scheme which I originally outlined gives a sufficient scope to the Engineer officer (as it does to the Ordnance officer) yet I am on the whole inclined to think that the ideas of the Chairman are better than those advanced by me: and I am quite willing to accept them in lieu of the plan stated in the essay, chiefly for the reason that it would settle the final destination of an officer more quickly than under my plan, which must be acknowledged to be a very important point; besides, there would really be still more of a selection for the permanent men than by my own scheme. (This earlier separation has also been spoken of by Mr. Manning.) I still think, however, and I believe that the majority of the officers in the service will agree with me, that these men ought to go to sea, let us say as fleet engineers, while in the grade of lieutenant commander; for I cannot but attach much importance

to sea experience (and that of a recent character) as being of great service to them in their duties on shore.

With regard to the method which I proposed for the amalgamation of the junior branches of the Engineer corps with the line, I offered it with a great deal of hesitation, and merely as being *some* solution of the question, feeling tolerably sure that it would be likely to meet the fate (which it has met) of not being agreeable to any of the parties concerned. It will be seen that my belief was not ill founded, for I have been liberally thwacked on both shoulders; so, perhaps, it would be well for me to let the matter pass with the statement that it was my object to merely indicate a way in which the proposed change in the state of the corps *might* be brought about at a comparatively early day, and thus the homogeneousness of the service hastened. No doubt other and better schemes might be devised if it were thought desirable to make the attempt.

My desire was to make the engineer corps, what it is not now, *the* corps of the Navy: and I am perfectly willing to submit to the judgment of the Engineers themselves whether it can ever be such under the present system, whereby we are graduating some twenty or more young men each year, the great majority of whom do not (as a rule) care particularly for their profession, and whose standard (as has been shown pretty conclusively by figures, not however intended to serve this purpose) is but little, if any, higher than that of the cadet midshipmen. We cannot have a body of more than two hundred and seventy (nearly one fifth of the entire service) as a highly scientific corps: to be such it must be small in numbers and not large.

So far as regards a change in the present system being desirable, I would quote the following from the report of the late Superintendent of the Naval Academy, the same report alluded to in the essay. "It is my carefully considered belief, that any lad of even less than average ability, can complete successfully the course of studies here, if he will study faithfully and diligently. Those of more brilliant capacity, can attain the same result, with a very moderate amount of study. To take honors at the school, requires both capacity and hard work.

It is sometimes claimed that the course here is too severe, and I venture to give it as my opinion that such is not the case, and I think that if the demands of the course were largely decreased, we should have no more graduates. As the demand decreased, the efforts of the student would diminish; *for it is now not the love of learning, but the fear of failure, which prompts the majority to exertion*; *and with the larger number the effort is to do as little instead of as much as possible.*"

In pursuit of the same line of thought, an officer remarked to me the other day that "there must be something wrong in a system in which education was so little attractive for its own sake, that most people rejoiced greatly when they graduated from the Naval Academy". Following this up I have conversed with some of the cadets of the first class, and I find that the general feeling in the school at present seems to be, that the tenure of office being secure so long as the minimum mark of 2.5 is reached, there is no special incentive to study and that the very great majority of each class are quite satisfied to graduate, without any special regard to their standing. There are always a few men at the top of each class who struggle among themselves for class numbers, but beyond these emulation does not (as a rule) extend. As to the existence of a general apathy among the cadets, I am quite sure that every instructor here will agree with me; but I believe that under the plan I have sketched there would be but little of this; during the first two years each youngster would be struggling for a place among the fortunate ones who were to become Midshipmen: and habits of study thus formed would be carried by the successful ones into the higher classes, and the general results being far better than those under the system at present pursued, there would be, as I have

stated, an opportunity to pursue higher courses than those now required, and thus the general standard of the school elevated.

I cannot think that a plan similar to that pursued in the Army, with regard to the corps to which the graduates are assigned immediately after receiving their diplomas, would produce as good results as that which I have presented (especially as modified according to the scheme of the CHAIRMAN) and the current of opinion in the Army itself seems to be quite in favor of details from the line and therefore adverse to this present system: I think moreover, that it would not tend to the point which is so desirable, unity, and with it increased efficiency.

With regard to competitive examinations, while I to some extent agree with what has been said, yet it must be remembered that a good many of the cadet midshipmen obtained their appointments through competition, as it is quite a common thing for a Member of Congress to offer the appointment in his gift in this way. If the plan which I have submitted should ever be followed it would give to a Member one appointment during each of his terms of office, and would thus open three chances for an honorable career to all the boys in his district, where now but one is offered, and that not always, as, in probably the majority of cases, the appointee is selected by the Member.

As to the matter of a second course at the torpedo school I am quite at one with the gentleman who has proposed it; I think it would be a very desirable thing.

So far as raising the standard of admission is concerned, I think that a glance at the examples of ill preparation given in a work entitled "History of the Naval Academy", written by the CHAIRMAN, would show that the schools of the country could not well respond to any demand for increased advancement in study preparatory to entrance to the School.

With regard to the matter of educating specialists among the men, it is my idea that a sufficient number for the necessary supply of seaman gunners can be retained and educated as such on board the apprentice ships: and if it should be desired to instruct them further in details of magazine work it could readily be done. I have known of an instance where the gunner's gang of a vessel overhauled and prepared in the magazine and shell house, the entire supply of ammunition, work which is ordinarily performed (I believe) by skilled civilian workmen. With regard to the education of the men in the Italian service, I would call to mind a remark quoted by Captain Luce in a paper read before the Institute in 1874, wherein he states in substance, that the commanding officer of an Italian vessel said that "his men were not topmen;" now I do not think that we have yet got to the place where we can afford to dispense with topmen; we want them.

As to the matter of a compulsory post-graduate course in ordnance, I differ from Lt. SOLEY: it does not seem to me to be necessary, unless an officer is going to make that a special object of study. I am not well acquainted with the course in Gunnery at the Naval Academy, but I should suppose that it would be difficult to keep the text book up to the latest date. I believe, however, that a good foundation is laid, and that if the Bureau of Ordnance would send its circulars to all officers, it would tend to keep them sufficiently up in that branch, for the ordinary duties of their profession. I think a voluntary course, as provided for in the essay, is quite enough.

There is one criticism which I have heard made upon the essay to which (though it has not been made to night) I deem it proper to allude; and that is that there is too much *reorganization* about it. I believe that a mere cursory glance at the subject will lead to that opinion; but I also believe that a more mature consideration of the matter will lead to the removal of that opinion, and that it will be seen that the question of education necessarily and perforce involves the other. It is, perhaps, unfortunate that such is the case, but in writing the essay I was forced rather unwillingly into that belief. Accordingly I endeavored to present a scheme for reorgan-

ization as nearly entire as possible; which involved the subject of the *numbers* of the permanent officers in the different corps; and these numbers were given with a view not only to showing in what way I considered that the duties should be divided, but also to pointing out the character of the positions which a line officer might expect to attain, if he should leave the line, for some other corps.

I have never had the assurance to imagine that the schemes which I have outlined are the best that can be desired. I am sure that there are many more officers than those who have spoken to night who could bring forward ideas more matured and more susceptible of practical application, if they would but do so. If, however, the efforts which I have made in this direction have succeeded in bringing out the opinions of others, and if in any slight degree the ultimate efficiency of the Navy of which we are all proud to be members is promoted, I shall feel that the object of my labors has been fully attained.

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# THE ENVIRONMENT OF THE MAN OF THE SEA.

By Medical Inspector B. F. Gibbs, U. S. N.

Mr. President and Gentlemen of the Institute:

The limits of this paper on the Environment of the Man of the Sea, will permit me to touch upon a very few of the many subdivisions of the subject, of which it should treat. To make a brief statement of facts, to expose manifest errors, possibly to attack a prejudice, or to express an opinion without perhaps saying anything new, is all I can hope to do.

The term Man of the Sea, whom it is the purpose of this paper to consider in his conditions of place and surroundings, has been selected because it describes and indicates that a large minority of those who pass the active part of their lives upon the sea do not enjoy the mastery of the craft of the sailor, nor do their duties or professions continually call them to the deck to take a part in the labors which involve the conduct of the ship. The profession of a seaman, as this generic term is employed to indicate the accomplishments of those who manage and work the ship, as has been said, gives but a portion of the strength of the ship. The term Mariner commonly designates, in addition to those who are sailors, all those who are employed in vessels cruising in salt water, coast or otherwise, and are in varied degrees familiar with the craft and profession of the sailor. The term seaman is moreover that used in the Revised Statutes in designating all who go to sea.

The arguments and statements which I propose to present may not be new to many. I shall seek to show in dealing with the physical and moral environment of the Man of the Sea, that his highest condi-

tion in these respects will have been achieved, when all the destroying influences and preventable diseases no more shall invade his habitation ; when light and air shall become so abundant in his eating and sleeping apartments as to enable him to perform those functions of animal life, with all the comfort which our civilization demands ; when it shall be no longer believed that the demoralizing influence of alcoholic indulgence is the secret nursery for sailors, and that " without rum we would have no sailors" ; and finally, when a man, who expends his bone and muscle in a ship at sea, shall not, accidents excepted, live with the belief that his life will be in the slightest degree abridged. On the other hand, under a more enlightened care for this environment the average life of the Man of the Sea, may have years added to its length.

In view of such considerations as to the character of a nautical profession, I shall for the sake of brevity in referring to the Man of the Sea, include every individual under the common name of *seaman*, without intending to imply that all these are skilled in the craft of those who are trained and classed under this generic name in the Navy.

The study of the environment of seamen in this paper is no more than an abstract of some of the Coördinate sciences composing that of Naval Hygiene. Deductions will be made from exact methods as much as possible, and from absolute or conventional laws. In short, the study will be but an application to the seaman of the science of Hygiene, which for the first time in our own country has been recently accorded a high and honorable position in the councils of state.

A minute description of those quantities and elements by which the seaman is environed, would be impossible in *all* those relations involving his health, and but a few will be attempted. We must be prepared at all times to antagonize these elements of disease as they appear in, or about a ship, in their hydra-headed enormity. Upon our skill in promptly recognizing these causes of disease and death, which may beset our lives at every turn, and from which we will not escape without a struggle involving all our powers of study and reflection, will depend our ability to meet and overcome a persistent foe.

In these efforts most valuable assistance can be expected from the methods of modern investigators. The accuracy of the microscope, or of the delicate thermometers now in use, and the precision of chemical quantities, all will give us, in competent hands, much in addition to what they have already done. Compared with such information, opinions simply, are worthless and should be disregarded. Not that sound

opinions which are the fruits of a lifetime in the service, are valueless, only that these, as well as others must bear the test of instruments of precision, and the ordeal of tabular statement whenever numbers can be introduced.

To elucidate this subject in all of its details, as it would be treated under the science of Naval Hygiene, the following are some of the subjects which would be elaborately examined and discussed, viz., The materials entering into the construction of the ship. Its outfit of naval stores and provisions. The character of the cargo: whether of passengers, live animals, dead bodies, in transit, or materials liable to spontaneous combustion. The keelsons of the ship and their dependencies: in stowage of cargo, arrangement and use of pumps, store rooms, coal bunkers &c. Prisons and their inmates. The berth deck, and all the apartments opening upon it, including such matters as air space and ventilation, to be accorded to each person living between decks, or may be entitled to his personal space there. The charge of the sick and their quarters. The recommendation of change of duties among the men when demanded by certain physiological and pathological changes. Suggestions of caution where men are exposed unnecessarily in performing duties which would endanger their lives or health. All the details of examination in enlisting men or boys for the service, in collecting statistics and in making reports of the same, seeking to correct the habits and morals of men, where in these respects their health may be endangered. To improve the condition, as occasion demands, of those employed in working and manœuvring the ship, as well as those employed in its interior; of those particularly, whose duties demand continual exposure to high temperatures in addition, perhaps, to the direct rays of the sun. To vigilantly observe the appointments made for all in their sleeping arrangements, so that each shall have a sufficient amount of air space, that his bedding is clean and dry, that his mattress cover is changed weekly, and that he shall not sleep on the deck. That the clothing is clean and of good quality and suited to the climate. That men shall at all times keep their skins clean, and when the temperature is below 50° Fah., that suitable shelter and warm water shall be provided for the purpose. To seek to correct all carelessness of person and habit. To carefully collect and compile all nautical influences of environment, particularly as to the character of the atmosphere both within and without the ship, in its thermometric and hygrometric character. To protest against overcrowding. To interpose barriers against infection and

contagion, and to adopt measures to destroy them, if the ship should be invaded. To study the best and most perfect means of ventilating, lighting, and cleaning the ship, adapted to all climates and temperatures, at sea and in port. To oppose excessive currents of air, and excessive introduction of water into the ship at any one time, under the erroneous idea that such abundance paroxysmally supplied, is necessary to preserve the health. To study adaptations, and the relative physiological effects of the duties performed in a sailing ship, compared with those in a steamer. A ship with guns or a ship without guns, and the effects of drill at the guns, and on the yards. All the external influences of heat, light, and electricity. The physiological and pathological effects of climatic changes, either on account of changes of latitude or sudden oscillations of temperature. The influences of the land and the influences of the sea. The physiological effects of the sea water at different temperatures upon the animal functions. The distance at sea to which the influence of the land, in some parts of the world, extends in its hygrometric and electrical power. The hygienic precautions to be taken to resist the effects of an extreme climate: in a hot climate, regarding refrigeration, renewal of air, bathing and drinking: in a cold climate, to study the best means to resist the excess, and, at the same time, preserve the hygienic condition of the ship. To observe the character and quantity of food, the manner of cooking it, and seeking to improve it in any respect, The quality and quantity of fresh water for drinking and sanitary purposes, particularly as to its source and composition, and manner of storing it. If from river, spring, or surface drainage, steadily bearing in mind that from this source the majority of diseases arise in hot climates. If the water is distilled examine it frequently, and seek to have its production, in this way, at sufficiently long intervals to insure its aeration and potability. To express a liberal and fair opinion upon the vexed question of the character of drinks in hot weather, influenced by the light of physiological and pathological experience. The quantity, quality, variety and preservation of the sea ration. The change of alimentations and introduction of condiments. The change experienced in the functions of animal life upon arriving in port, and whether its apparent effects are injurious. And finally, not the least of all, the Régime of Moral Influences, considering the special conditions to which a seaman in the Navy is subjected. Also the Régime of discipline in all of its phases for good or for evil during the long and trying ordeal of a three years' cruise in the Navy.

The above points in a systematic work would be elaborated in detail. In this paper I can discuss but a few points touching the intimate physical and moral environment of the seamen, in regard to those surroundings which are so actually interwoven in their lives, that not only may health be affected and life shortened, but the habits, character, morals, bearing, and intelligence are surely moulded and influenced for good or evil, by these insiduous causes.

I shall select from this vast range of subjects in Naval Hygiene, the following, because they are most closely connected with, and most closely do environ the life of the seaman. 1st. The air he breathes. 2nd. The sweet and bitter water daily bestowed and appropriated for his use. 3rd. The comforts and conveniences which are arranged and dedicated to his retirement, repose, and sleep, and the varied influences affecting his character.

Life is a process which is marked by comparatively rapid change. As it is exhibited in animal existence, it is influenced in untold and inscrutable ways by its immediate surroundings. During its manifestation in this body, it is purely an existence of relation. It is, according to the definition of Herbert Spencer, which is perhaps the most complete, "The continuous adjustment of internal relations to external relations."

The most important environment with which mankind is continuously connected on shore and afloat, sleeping and waking, is that of Air. The study of this gas, by which all vital action is maintained and the temperature of our body is preserved, is a most extensive one. It is one of those influences, in the complexity of causes, which, if impure, affects the health and produces disease in the maritime profession.

We have always, however, to congratulate ourselves that the atmosphere of the sea upon mankind, may be considered generally more conducive to health than disease. This refers to the "blue water" seaman. The air is more pure on the sea than on the land. The saline particles which are held in suspension near the surface of the ocean, by the action of the mildest breeze, are taken into the lungs at each inspiration without injury, and in ordinary hygrometric conditions of the air, with advantage. But the saturation of the air by water, plays a part in the production of disease, generally injuriously affecting the health of seamen, which it is one of the objects of this paper to consider further on. In a paper which I wrote on "Ventilation in Ships of War", published by the Bureau of Medicine and Surgery in 1874, it is stated—"While a ship may be cruising in a lati-

tude or locality of notably pure atmosphere, or at anchor in a healthful port, we contend, that unless the temperature is low or changes sudden with a humid atmosphere, the environment for this ship is particularly good for the preservation of health. The approaches are unobstructed, and pure air comes from every direction."

In the movement and physical properties of the air there are a few points worth observing. The direct influence of the irregular or diurnal movement of the barometer upon the human economy, at the sea level, is not worth considering. Such barometrical changes indicating certain meteorological disturbances are of interest in hydrographical medicine. The animal economy is capable of accommodating itself to wide barometric changes, attended with some temporary inconvenience. Such effects are experienced in the transit of a few hours by rail in Peru, So. America, from the sea coast to the summit of the Andes of seventeen or eighteen thousand feet. Climatic differences here shown by daily comparison between the sea level and this great altitude, only a hundred miles asunder, exhibit contrasts worthy of further study, but have no particular connection with the present paper.

Although the seaman has no occasion to visit such regions, aside from curiosity, yet it is within the scope of this paper to introduce some facts showing the effect of this change in the physical condition of the air, upon the human economy and the relation of cause and effect arising from a special environment.

The native Indians of Peru are not peculiar, when we consider their acquired physical peculiarities, in selecting the high mountain regions for their homes, and seldom or never leaving them. They are born with an acclimation, so to speak, which is imposed upon any one who for the first time ascends these great altitudes. Such temporary disturbances are relieved by descending, but are serious and sometimes fatal if the cause remains operative. Under such circumstances the pressure of the air and consequent quantity of oxygen is reduced, and the number of respirations is increased, in order to obtain the amount of air necessary to carry on the functions of life. This increased effort at respiration is usually accompanied with faintness, nausea, and vomiting. More severe symptoms, such as hemorrhages, forbid a higher ascent.

Once accustomed to these altitudes the functions are easily performed, the digestion is easy and the appetite increases. Instead of fatigue, long journeys are made with the greatest ease. The passions and sensations are active, but the functions of respiration and circula-

tion accommodate themselves to these altitudes by obliging a decided morphological change in the individual. The measurement of the girth of the chest, during a residence of two years, I have known increased four inches in consequence of this increased demand for air. The average girth of the native mountain Peruvian, as determined by many measurements made for me at Yauliyacu, an altitude of sixteen thousand feet, by Mr. S. W. North, Civil Engineer, is remarkable when we consider the stature. The average age, as near as could be approximated, was twenty years. The average height was five feet two inches and the girth of the chest was thirty-five inches. There was one boy with a chest measurement of thirty-six inches who was but fourteen years old and four feet ten inches high. No less surely and insidiously do the physical changes of the outside air operate upon the life in the ship, and on it.

The injurious effect of various kinds of winds upon the vitality, depends entirely upon the rate at which they blow, whether excessively hot or cold, or whether excessively dry or wet. In fact the pernicious effect of any meteorological peculiarities of the atmosphere depends upon its excesses. In the rapid or sudden evaporation which occurs when the body is covered with wet clothing or perspiration, and is exposed to wind, the danger of a subsequent inflammatory disease is in direct proportion to the lowness of temperature and strength of the wind. These results, in the form of pneumonia, pleuritis or rheumatism of an acute character, are well known to all. On board ship they are matters of almost daily occurrence from various kinds of exposure.

As is well known from common observation, whether a wind is dry or wet depends upon whether it comes from the land or the sea. The amount of moisture, if from over the sea, usually depends upon its temperature. An atmosphere thus saturated at an elevated temperature and cooled down by a sudden change of wind to a lower temperature, places those exposed in the greatest danger, and some of its results are quickly apparent in the diseases following. Warm winds, and as they are usually at sea, moist winds, are not attended with so much immediate danger. Their effect is depressing and continuous. The free evaporation is restrained, breathing is more difficult and less oxygen is contained in the same volume of air. While hot winds from the sea contain this abundance of water, the hot winds coming from the land have, perhaps in place of water, the fungoid elements, pollen, animalculæ, sand, and whatever the land produces which can be carried in the air. Under these circumstances the skin is hot and dry and the

thirst excessive. The east winds which occasionally prevail on the west coast of Chili and Peru cause, as I have witnessed, the extraordinary phenomena of a difference of twenty-five degrees between the dry and wet bulb thermometers. These observations were made by Lieut. S. W. Very, who, I may say, is celebrated for accuracy in such matters.

That winds can transport the morbific germs of disease and deposit them in their paths there can be no doubt. Such facts have been gathered in abundance, and formulated by science. The emanations from marshes are well known to be carried long distances by the winds. The germs of yellow fever, cholera, enteric fever, and, in fact, any disease, which is communicated by a specific poison, may be carried in the same way. Observations are not extensive nor accurate enough to determine the meteorological conditions under which epidemic influences prevail. Each epidemic disease seems to require something peculiar. While, for instance, yellow fever never prevails unless a certain high temperature is reached, cholera, small pox and typhus fever prevail at a much lower temperature.

All of these influences, which are carried by the air in its varied physical characters, bear directly and peculiarly upon the seamen. No life is so exposed to climatic changes. In addition to exposure in one locality, the home of the seaman passes quickly from one latitude to another. The intense cold of a high latitude is thus changed in a few days to one beneath the direct rays of the sun. Or the reverse of this, so that if a protection is not secured to correspond with these oscillations of temperature and climate, disease and suffering must follow. The education required to enable one to observe those details by which the health of a seaman is preserved, can only be acquired by experience. If rules could be written they would be worth buying at any price. Daily and hourly precautions are often necessary, in eating, drinking, sleeping, waking, working, conversation, dressing, washing, and in exposure in a thousand ways, the rules for which would not be heeded, nor remembered if heard, and only too often are taught by bitter experience.

In addition to the above physical changes, the air undergoes modifications in its gaseous constituents. These are quite numerous, and while some are accidental others are constant. Under varied unhealthful conditions where animal or putrescent matters are found, we have the evolution of carburetted, sulphuretted, or phosphoretted hydrogen. Ammoniacal gas is at all times disengaged in a ship, but more particularly, if certain vegetable matter is suffered to decom-

pose, which may compose the fresh provisions of the ship, like cabbages or potatoes. All of these emanations have a direct influence in producing grave diseases of the eyes, throat, lungs and skin. We are further informed by such pathological evidence that there is a source of disease which demands immediate attention, if before unobserved.

No modification of the gaseous constituents of the air interests us so much as that of Carbonic acid. After the general statements here made regarding the effects of winds upon the human economy, and which are the deductions of a life time, it will be a relief to the skeptical regarding such rational conclusions, to turn to more exact methods for measuring the causes of disease. Fortunately for us, while we recognize in carbonic acid gas, as a product of respiration, combustion, and secretion, in conjunction with water suspended in the air, one of the most formidable of the environments which antagonize the life of the seaman, gradually overcoming it by the slow approaches of subtle disease, we are in possession of means of measuring the amount, not only of carbonic acid with the utmost precision; but the humidity of the air is measured down to minute fractions. The very facility and extreme accuracy with which these measurements are made, hold up to us the brightest promise, that our exact knowledge of the existence of these conditions of disease, will lead us to combat the circumstances necessary for their production and positive abatement.

The Bureau of Medicine and Surgery is already in possession of a mass of statistical information regarding the amount of carbonic acid found on board ship, as well as the hygrometry of its different parts under different circumstances, which have never before been collected. The officers in our navy have been among the first to systematize the labor of this field. The first published report of this work done with a view of determining the amount of carbonic acid in the ship, was made during my tour of duty as Fleet Surgeon of the South Pacific Fleet in November, 1874, by order of the late Rear Admiral Collins. The chemical examinations were made by Lieut. J. F. Meigs, and Assistant Surgeon Howard Smith, U. S. N. These officers purchased their own anemometers and instruments for chemical examination, exhibiting a most commendable zeal in their labors. Medical Inspector Turner has since systematized these examinations for determining aerial impurities, giving them uniformity, and reliability for accuracy of instruments, in determining the meteorology of the interior of the ship. Without accuracy it is worse than useless to take any meteorological observations. Some time since, to show how useless are such records

as have been kept on board ship, wishing to obtain some information regarding air temperatures and the hygrometric condition of the same at Callao, in 1868, when the terrible epidemic of yellow fever of that year made its appearance there, I examined the log books of two vessels then lying together in the bay of Callao. These vessels were the *Wateree* and *Nyack* and the subjoined extract is taken for a week only to show these differences, viz., from the 21st to the 27th of March inclusive, 1868, just before these vessels left for Africa to escape the fever. The average difference for all the different registrations, taken six times a day, in the wet bulb thermometer, is four degrees, and for the dry-bulb, one degree. Of course averages show nothing, plus and minus quantities balancing. The exact figures are therefore furnished in the accompanying comparison, from the log-books of these two vessels. The differences of temperature for practically the same moment range as high as twelve degrees, (21st noon) in the two records of the wet-bulb thermometers, and eight degrees in those of the dry-bulbs. Variations of three and five degrees are frequent, smaller ones almost constant and in but one instance, viz., on the 25th at 8 A. M., do the records for the two ships agree. The steadily higher marking for the wet-bulb of the Nyack shows some constant error. Several times however it fell below that of the Wateree and these differences were never a constant quantity.

| 1868. March | WATEREE. D. B. | WATEREE. W. B. | NYACK. D. B. | NYACK. W. B. |
|---|---|---|---|---|
| | **4** | **A. M.** | **4** | **A. M.** |
| 21 | 72 | 68 | 70 | 68 |
| 22 | 72 | 70 | 72 | 71 |
| 23 | 70 | 70 | 74 | 72 |
| 24 | 75 | 70 | 71 | 72 |
| 25 | 71 | 71 | 72 | 72 |
| 26 | 70 | 68 | 71 | 71 |
| 27 | 72 | 70 | 71 | 70 |
| | **8** | **A. M.** | **8** | **A. M.** |
| 21 | 74 | 71 | 71 | 69 |
| 22 | 74 | 72 | 75 | 72 |
| 23 | 74 | 72 | 76 | 74 |
| 24 | 78 | 72 | 74 | 72 |
| 25 | 74 | 72 | 74 | 72 |
| 26 | 70 | 68 | 72 | 71 |
| 27 | 74 | 70 | 71 | 70 |
| | **N o** | **o n.** | **N o** | **o n.** |
| 21 | 80 | 72 | 79 | 60 |
| 22 | 79 | 75 | 79 | 76 |
| 23 | 81 | 73 | 77 | 74 |
| 24 | 83 | 73 | 75 | 74 |
| 25 | 78 | 70 | 74 | 72 |
| 26 | 73 | 71 | 72 | 71 |
| 27 | 75 | 72 | 70 | 68 |
| | **4** | **P. M.** | **4** | **P. M.** |
| 21 | 79 | 76 | 76 | 74 |
| 22 | 77 | 73 | 76 | 74 |
| 23 | 77 | 72 | 78 | 76 |
| 24 | 77 | 73 | 74 | 72 |
| 25 | 73 | 72 | 73 | 75 |
| 26 | 75 | 72 | 78 | 76 |
| 27 | 78 | 73 | 70 | 68 |
| | **8** | **P. M.** | **8** | **P. M.** |
| 21 | 76 | 72 | 71 | 76 |
| 22 | 72 | 71 | 76 | 74 |
| 23 | 74 | 72 | 76 | 74 |
| 24 | 72 | 72 | 74 | 72 |
| 25 | 69 | 69 | 72 | 70 |
| 26 | 70 | 69 | 74 | 72 |
| 27 | 71 | 70 | 74 | 74 |
| | **Mid** | **night** | **Mid** | **night** |
| 21 | 73 | 70 | 72 | 72 |
| 22 | 73 | 71 | 74 | 72 |
| 23 | 70 | 69 | 73 | 72 |
| 24 | 71 | 70 | 71 | 71 |
| 25 | 69 | 69 | 74 | 72 |
| 26 | 71 | 70 | 74 | 70 |
| 27 | 70 | 68 | 72 | 72 |
| Totals | 3036 | 2981 | 3090 | 3019 |
| Av'ge, | 74° 28-42 | 70° 41-42 | 73° 24-42 | 74° 11-42 |
| | D. B. | W. B. | D. B. | W. B. |

Many times in my life in the Navy I have noticed the wet bulb thermometer taken and recorded from the state of the mercury observed after the cup surrounding the bulb had been kept filled with water for some time. This was, indeed, a "wet bulb," but not a good way to determine the rapidity of

evaporation, as a measurement of the humidity of the air. Some careless practice of this kind may account for the differences in the above vessels. In case these differences may have been owing to the character of the instruments, at the present day no excuse of this kind should prevail, as those now provided for the service, both for the deck, and meteorological measurements of the interior are fairly tested before being supplied for use in the important service to which they are adapted. It is now upon these instruments that we rely for our knowledge of the watery impurities of the air, and in noting the excesses above a given and determined standard.

Carbonic acid, the modern dioxide of carbon, exists naturally in the air overlying the land, and is caused by vegetable growth, combustion, respiration, decomposition, &c. On the open sea in a ship, but two of these causes, viz., respiration and combustion, should be active generators. These are enough to extensively vitiate any confined space with this gas, and in such quantities as to be injurious to health, and, therefore, require watchfulness. While carbonic acid which is chemically pure may be taken into the stomach without injury, it cannot be inhaled without endangering life, and much smaller quantities mixed with *organic matter* produce serious results. For means of making examinations for this gas I refer to works on general and special Hygiene, and Chemistry; and particularly for an account of some experiments, to the appendix of circular No. 4, War Department, Surgeon General's Office, 1870. Any one, with little care and ordinary chemical knowledge and familiarity with apparatus, ought to be able to determine the amount of organic matter and carbonic acid in the air.

It is not necessary to further enter into the figures representing carbonic acid, than to state that there is almost always found in outside air, four one hundredths (0.04) of one per cent. of this gas. Or four tenths (0.4) of one volume, or cubic foot, in 1000. Or four (4) volumes per 10,000. There is admitted 0.2 of one volume in 1000 to be added to the normal 0.4 of one, making 0.6 of one of carbonic acid in 1000 volumes. Beyond this the air becomes practically impure. First it affects the senses and next the more important physiological processes. Upon entering a room in which the air contains the allowable quantity of impurity, viz., 0.6 of one volume in a thousand, there is nothing discoverable to the senses. In a room where the $Co_2$ has reached 0.7 of one volume in a thousand, the smell of organic matter is very perceptible. When it reaches 0.8 of one volume, the

room smells "stuffy." It becomes very strong and oppressive at 0.9 of one, to the unit of a thousand volumes. Pettenkofer found in a girls' school where but 150 cubic feet per head of air space was allowed, the enormous quantity of 7.23 volumes in 1000! And yet if you will turn to the Reports of the Bureau of Medicine and Surgery you will find that this cubic space is much more than is usually allowed below to each man on board ship. There are however in the Navy allowable compensations for this paucity of air space, where natural and artificial advantages are properly exercised.

In the *Richmond*, during my last cruise in her, she was provided with but a single deck, so that each man on the berthing room of this deck was allowed but 56 cubic feet of air space. If the ward-room and steerage countries were included in the estimate it reached the general average of 150 feet, just Pettenkofer's school room figures, but with signal advantages regarding apertures for admission of air. Dr. Craig, U. S. Army, found in a casemate of Fort Hamilton, where each man was allowed 260 cubic feet, 1.4 cubic feet of carbonic acid gas in 1000 of air, which he considered so unsuited to the purpose of a dormitory, as to recommend that it be no longer used as such. In the paper before mentioned by Messrs. Meigs and Smith they found in port, on the berth deck just abaft the sick bay bulk head, 3.41 vol. of $Co_2$ in 1000 of air. They also found in the wardroom with one sky-light open, and all candles and two lamps burning, and air ports in, 2.27 volumes in 1000. This limited ventilation was enough to diffuse the carbonic acid, but the experiment is yet to be made as to what we will find with a ship under battened hatches, for a long period, where no provision is made for ventilation. More will be said of this subject under the head of ventilation.

The carbonic acid alone is not the cause of vitiation and the nauseating odors emitted from a confined space. These arise from the organic products of respiration and exhalation. Yet the amount of carbonic acid is taken by all sanitarians as a fair index of the amount of organic matter exhaled at the same time. Nothing much is known of this organic matter, except that it is nitrogenous and oxidizable. If any one wishes to procure a nasal demonstration of its fetid character, let him breathe in a large bottle in a cold day, or have it surrounded by ice. As the water of respiration is condensed in the bottle it dissolves and collects the organic matter. If now the bottle is inverted on a plate, the few drops of water collected will send forth the odor

which may be distinctly recognized as that of the berth deck, or sick bay, of a vessel in commission.

The figures, upon the subject of the products of respiration, combustion, fermentation and other air impurities are enormous and will not admit of being followed here.

*Ventilation* is a subject to which some space must be devoted as it antagonizes air impurities, and as it is occupying at the present day, as it should have done fifty years ago, a large share of attention by those who are interested in Naval architecture, or in improving the sanitary condition of seamen.

Ventilation is one of the subjects treated of in works on Hygiene which demands the exercise of the most philosophic study. It is also conventional in its character, yielding to conditions of time, locality and physical circumstances, in drawing conclusions. One person may be satisfied with an air less pure than another, and live without inconvenience or resulting disease. Others demand a practically pure atmosphere and are willing to undergo the exposure attending the requirement. The excesses of climate, viz.; in heat, cold, moisture, and dryness with that most important factor, the movement of the air, all most intimately enter into the subject, and no consideration of it would be complete which did not accord to each of these its proper value in drawing practical conclusions. The purpose for which a structure is intended must influence the arrangements made for ventilation. For instance a hospital requires from two to six times as much space per man as a barrack, and barracks usually get three or four times as much space per man as is allowed in a ship. Under all circumstances the dormitories used by persons in health demand a judicious increase of air at night, which might be useless and even dangerous in the day. It will be necessary to place before you briefly some numbers, and a few of the accepted conditions of this important subject.

We are bound by every sentiment in humanity, and by every consideration which seeks to secure the highest interests of the service, to furnish to every man in the ship the largest cubic space which it is possible to assign in the nature of things. I am satisfied it is possible to so construct, arm, and equip ships, that each man shall have 300 cubic feet for living purposes. It should not be less than this if his health is to be fairly preserved, amid exposures to vitated air and the trials of the sea.

In illustration I will take the case of the *Richmond* before referred to, in which I served four years last cruise in the Atlantic and Pacific

oceans. The total area of square surface of aperture of admission for air, compared to the total cubic capacity of her decks, supposing her to have had a spar deck for accomodation, is exceedingly favorable. Her air space with such increased capacity would only be about 225 cubic feet per man. The apertures of admission were so large as to require but a slow movement of air to completely renew this cubic space as often as necessary. I may say that unless impossible, no ship should ever be built without a spar deck, if we wish to secure the best hygienic results, beside providing additional safety.

This 300 cubic feet of space to each man must be exclusive of incumbrances. In order to realize the practically pure atmosphere, it must respond to the tests, a purity which shall exhibit no more than 0.6 of one volume of carbonic acid in 1000 volumes of air. According to Pettenkofer's experimental room this 300 cubic feet will be vitiated by one man, unless it is completely renewed 13 times an hour, supposing 3000 cubic feet per man per hour necessary. Through his small apertures of five or six inches square, this could not be done without danger. Quite different are the hatch apertures of a ship. This passage of air through the hatches of the *Richmond* would not be excessive, even if cold and wet. Air should not pass more rapidly than three and a half feet a second or 2½ miles an hour. Otherwise a sensation of cold will be produced, particularly if the air contain the night moisture. At one and a half feet per second, air is scarcely perceptible. Hence warming becomes an important consideration in any system of ventilation. We must not rest satisfied in the Navy with a less aggregate possibility than 3000 cubic feet, per man, per hour. In submitting to a less quantity, would be equivalent to an acknowledgment of our ignorance, and our inability to avail ourselves of the engineering skill we have in the service, to provide for our own health and comfort.

In the *Richmond* in 1876 there were about 425 square feet of air apertures to the berth deck. There were, with air ports closed, (the only true test of applied ventilation for a ship,) more than 300 superficial feet of hatch openings, With a spar deck she will have full 80,000 cubic feet of clear berthing room. This would give for 350 men 225 cubic feet each. Given 350 men and officers and 3000 cubic feet of air for each, it would require that this 80,000 cubic feet be changed 13 times in each hour, because 350 men multiplied by 3000 cubic feet gives 1,050,000 cubic feet, which divided by 80,000 is near thirteen. Two thousand cubic feet per man, per hour, will require that this air

space be renewed nearly nine times an hour. One thousand cubic feet, per man, per hour, will require this air to be renewed about four times per hour. But I believe that 3000 cubic feet per man, per hour, and even more, can be safely supplied through the above described hatches, unless the air is very cold and saturated with moisture.

The supply of air to the berth deck of the ship, in passing down through the 300 square feet of open hatches, at the rate of one and a half feet per second which Parkes says at 55° or 60° Fah. is not perceived, will give the enormous supply of 1,620,000 cubic feet per hour. Be it remembered the total required for these 350 men and officers to give each 3000 cubic feet per hour, is but 1,050,000 cubic feet!

Air moving at the rate of one and a half feet per second, will pass through this 300 square feet of open hatches so as to deliver about 450 cubic feet per second. The total amount of cubic feet required to supply the 350 men with 3000 cubic feet each per hour, is 1,050,000 cubic feet. The number of seconds which will be required to effect this change, will be given in the number of times 450 is contained in the whole cubic amount of air, which is 2333+. An hour containing 3600 seconds, we have for the time whereby this change shall be effected, and the proper purity of the air preserved, a fraction of an hour equal to about forty minutes. We have therefore in the given apertures an area, which in one hour will allow, at the above velocity of one and a half feet per second, a supply of air one half greater in amount than necessary, or 4500 cubic feet per man, per hour. We have the 80,000 cubic feet of the respiratory air, or 225 to each individual, changed through these enormous apertures, more than twenty times an hour, and at the low velocity above indicated over the decks.

Hence we find the capacity of the hatches for a pure air supply to the ship's interior beyond all ordinary needs. How the air is to be *obliged* to find its way to every part of the interior of the ship is indeed the most vital question in connection with an improved environment of the seaman and removal of hidden dangers of disease. In connection with this part of the subject I offer some experimental knowledge. The successful ventilation of ships in the English navy and merchant service has been established for twenty years, and with them such success is no matter for surprise. The plan originated with them, as will be presently shown, one hundred and thirty years ago.

Permit me to say, having already given considerable study to the subject of preserving the interior climate of the ship in a reasonable degree of purity, as well as devised plans for securing the same, and as

we have shown that the grand apertures of the ship are usually more than sufficient for the air ingress, I believe any system will be successful at ordinary temperatures which provides for the removal of vitiated air from the interior, by heat or mechanical means. The external air will descend through the iron masts, open hatches, or any other arranged apertures, if *obliged* so to do by applied power, which shall cause the air to make its exit through longitudinal ducts placed properly in the wings of the ship beneath the decks.

This plan for ventilating a ship by the extraction of air is now believed to be the best. But no one can claim originality for the idea, or for its application at the present day, as it is very old. The first knowledge we have of its use in practice was by James Sutton of Edinburgh in 1749. A description of the plan was published in that year, with a treatise on scurvy, by Dr. Mead and was called " A new method for extracting the foul air out of the ships." A system of pipes connected in the hold of the vessel, were joined and led to the ash pan of the galley-fire. It was eminently successful so long as the ash pan doors were kept closed. Then by Th. Day in 1784 who published an 8 vo. volume, " On the removal of confined and infectious air." Then by Pajot des Charmes, who published in 1812 an 8 vo. volume, " On the use of Caloric, which is lost in the chimneys of forges and heaters of factories, for ventilation and in heating." The same system was used by Péclet and Duvoir in Paris in 1842, and by numerous others both in France and England. The same plan of extraction was employed by Dr. Mapleton in the hospital ships in China in 1860, in the English and French war against the Peiho Forts. In all these the air is drawn through the horizontal induction pipes and delivered into the space around the smoke pipes or chimneys. So that fire rooms are reduced from 130° and 140° to 60° and 70° Fah. " This same principle has been applied by Admiral Fanshawe, late superintendent of the Chatham dockyard, England, to the ventilation of every part of the ship where there are no water tight compartments."—Parkes.

There are other studies of impurities found in the air of the seaman's environment which should be mentioned although it will be hardly possible to do more. These impurities consist of material existences or substances which chemical or microscopical investigations have thus far been unable to determine. These are the miasmatic emanations from decomposing animal substances, existing in the putrefying fluids or in the surrounding air: and the material poisons producing Intermittent fever, yellow fever, &c.

Under this comes that undefined exhalation which is experienced in confined air, the organic matter of the air, produced by animal respiration, exhalation and secretions which is felt and known to exist at all times in a ship. It is found in its greatest intensity often in the wards of a hospital, where fevers and diseases or suppurating wounds, so poison the air as to cause the abandonment of the building or its destruction.

The seaman is exposed to all the diseases to which mankind is liable, whether they be those purely epidemic like cholera, yellow fever, the oriental pest or plague, or those miasmatic influences which are accidentally epidemic, like dysentery, cerebro-spinal-meningitis, or the stronger miasmatic emanations of contagion, like small pox. The causes of epidemics have occupied the minds of the most earnest hygienists in all the history of the past. The belief will probably always be entertained, that such diseases have their origin in germinal matter which is capable of being wafted in the air for longer or shorter distances, or of being transported in ships. The confined air of the hold of a ship whether clean or foul, seems to be the home specially preferred for some disease-germinal matter. But it must not be understood that this germinal matter has ever yet been determined. Various devices have been arranged to collect it where it has been supposed to exist. Gigot, in France, arranged an aspirator for collecting germs of marsh malaria, as were plates of glass fixed by our own countrymen, Mitchell and Salisbury, for the same purpose. The latter supposed that he had discovered the cause of Intermittent fever in the sporules of a cryptogamic plant, the Palmella. Lionel Beale says that such germs have not been demonstrated as causing disease, that the most lowly germs discovered by the highest powers, have been discovered circulating in the blood, and which have been mentioned as causes of epidemics when found outside the body. The seaman must be content when he finds himself environed by disease, to make his home as pure and sweet as possible, and then in case of necessity do what a man does when his house takes fire, leave the locality and the disease in the home of its birth.

*Water*—We must hasten to the next part of our subject, that of the relation of the water the seaman drinks, which is appropriated to his use in other respects, and by which he is environed whether sleeping or waking: I am sorry that I cannot, in my experience with water in its varied relations to the life and health of the seaman, make such a satisfactory statement for the present, nor one filled with such bright

possibilities for the future, as I have concluded regarding an abundant supply of pure air. Yet in some respects there has been an improvement in the use and abuse of water, and in others much remains to be done.

The temperature of the sea we all know controls the temperature of the air. On account of this great capacity for heat, where the water of the equator is carried toward the poles the air above it is elevated in temperature and has its hygrometric condition increased. A slight fall of the temperature under these circumstances produces dew, fog, rain, or hail. In this simple statement we have the elements which are prolific causes of disease and are the enemies which continually beset the life of the seaman.

The atmosphere of the sea is less variable than that of the land, and is moreover heavier than in most of the inhabited parts of the globe. The temperature of the sea air is more constant, the winters are less cold and the summers less hot. A certain humidity continually prevails from evaporation and almost constantly saturates the air. Analysis proves that the air of the sea contains a little less oxygen than that of the land. But this slight diminution is largely compensated by the increased pressure. It may be said to the practically pure, with the exception of the water it contains, and the impurities imparted by the ship in which the seaman lives. The most marked effect upon the atmosphere of the sea is shown under the influence of the land on the coasts. Here the seaman is exposed to particular dangers from saturation of the air and oscillations of temperature, as well as from the miasma of disease produced upon the land.

As the seaman thus lives in an almost saturated atmosphere it may be said that the fall of temperature of the air, is a direct measure of its injurious influence upon the animal economy.

Heat in dilating the air renders respiration more frequent. The temperature of the body is also increased in adults one or two degrees in the tropics. When to the increase of temperature we add the naturally increased humidity, new conditions are imposed upon the function of respiration. There is an increase of depression because the lungs cannot relieve themselves of the water contained in the pulmonary exhalation. We have all felt this while our skin has been bathed in perspiration, this secretion of the watery part of the blood through the skin, being an attempt of nature to compensate for the reduced watery exhalation of the lungs. The perspiration becomes sensible on account of the saturation of the air. The relief one feels

under such circumstances, from a very sudden and somewhat dangerous change of climate, is abundantly illustrated on our southern coast at Pensacola, Mobile, or New Orleans, where within three hours I have known a change of 20 degrees, from the stifling oppressive atmosphere of the south winds of the sea to the clear dry winds of the north. This must be felt to be appreciated in its physiological and pathological realities. It has been said that subjection to a persistent humid atmosphere is productive of obesity of the body, and obtusion of the intelligence. We are sure that the appetite is enfeebled and uncertain, and the muscular and nervous systems become debilitated.

Perhaps one of the most important relations for a seaman to consider in his environment of heat and humidity, beside those just mentioned, is the increased activity of fermentation and decomposition in the ship in consequence of these conditions. No air is so favorable to the production of fungus growth as that of heat and humidity. Such growths pervade animate as well as inanimate objects and for the present, our power to overcome such growths if possessed, is seldom applied. The deleterious principles which are evolved by these influences, not only from fungus growths, but the putrid fermentation and decomposition of organic matter, evolving dangerous poisons are absorbed and carried by the watery vapor.

After several months at Panama our shoes and clothing were covered with mold. I used a box in my room for keeping my shoes which shut almost air tight. These were here covered with mold. I saturated a sponge with impure carbonic acid and after placing it in the box was pleased to find within a few days all the mold had disappeared. I afterward put my clothing in this same box and the mold was completely killed. Captain P. C. Johnson experimented with carbolic acid in the *Hassler* on the awnings, to observe its effects in preserving them during their continual use in the humid atmosphere, on the west coast of Central America. He covered one half of the poop awning with carbolic acid and its effect was, that when that part which had *not* been covered was destroyed by mildew, and rotten, the other part was perfectly good. He made a special report of it at the time.

While carbolic acid may in the future be used as a destructive disinfectant for the arrest of the low forms of life, and destruction of disease germs in the ship, the direct effect of humidity of the atmosphere in the same place, cannot be abated by any chemical means with which we are acquainted, without *increasing the temperature.* There

is no use to dwell upon the direct disease producing character of such an atmosphere.

The various affections of the lungs and throat and the settled rheumatic affections which we are called upon to treat, and the government to pension, have their remote cause in this very atmosphere, the interior ship climate. And while it is often impossible to fix any particular act of duty which gave rise to chronic rheumatism, or consumption of the lungs, the phrase "from exposure to climatic causes" in most cases, is intended to refer this very atmosphere which prevails in the inside of the ship, to this saturation from natural evaporation from the sea, the excessive mechanical admixture of saline particles, the vitiation from secretion, excretion, respiration, decomposition, fermentation, and putrefaction, to which is too often added unnecessary deluging for a prolonged period the various decks with salt water, all of which constitute the direct and continually acting causes of the diseases, which make the aggregate of those quarterly reported to the Bureau of Medicine and Surgery.

Next to a pure atmosphere all those auxiliaries are demanded to preserve the health of the seaman, which give us an air not more humid than the natural sea-air, while at the same time the perfect cleanliness of the ship in her interior shall be preserved.

While it has been said there are no precise rules by which the health can be insured any more for the ship than the shore, continual vigilance in preserving a *dry air*, a *pure air*, in a *clean ship*, will "fill the bill" as well as any other general direction relating to the physical environment of the seaman. Such important, yet simple facts, it ought not be necessary to mention before the intelligent minds composing this body, to receive an approval which years of experience have accorded them.

The importance of that use of water which effects perfect cleanliness of person, in a ship, is fully acknowledged. In my experience in the Navy, it is one of those things usually observed. If an exception occurs it will not be found among the older seamen, and is sure to occasion remark and an avowed dislike to the individual.

That other use of fresh water, for drinking, I will only refer to for the purpose of expressing my admiration for distilled water for this purpose—for the seaman's use. To be sure a perfectly acting filter will make river water as pure as we need it. Impurities are by this means practically removed. Yet men will use it without being filtered if the allowance is not restricted. The filter may get out of order, and the

water cease to be relieved of its impurities, long before the discovery is made.

Those diseases which were, years ago, the scourges of the seamen, dysentery and diarrhœa, may be said to be practically banished from the Navy. The causes are removed as completely as are those of the now almost historic scurvy. I will only mention one fact, which is worth more than pages of argument. In the sanitary and medical Reports, published by the Bureau of Medicine and Surgery for 1873 and 1874, Surgeon H. C. Nelson compiled, from the medical reports for those years, the deaths in the service from all causes. There were but *five* deaths in all, from these diseases, viz., two from chronic diarrhœa and three from acute dysentery, in *two years*, for the whole service. These occurred on the Asiatic Station. During a cruise I made in the *John Adams*, in China, of about twenty months, on the station proper, we lost, in this ship alone, seven men from dysentery, and eleven more were brought home in the ship, more or less permanently invalided. We used river water, when these diseases occurred, which was filled with organic matter, and it was used from over the side without filtering. From Anger, in Java, we took water from an impure stream which runs through the rice fields, as we were obliged to do, and, although the fermentation of this water filled the ship with the most sickening odor, it was not purified by the exhalations, as the disease of the climate began with our entrance upon the station. Such facts, which are abundant, furnish the most conclusive evidence of the value of distilled water.

One more instance occurs to me of the *use* of distilled water for the relief of dysenteric affections where these are endemic on account of the impurity of the water. In Valparaiso, in the summer of 1876, when these dysenteries are the prevalent disease, and exceedingly fatal, I attended a lady on shore, who had recently arrived in the country, and was suffering from acute dysentery. Pure water there, at this season, is most difficult to procure, and all of it contains organic and mineral impurities. In this case I gave no medicine, but directed her to procure ten gallons of distilled water and use no other, not even for washing. In four days she was completely relieved and her health restored. This is not a peculiar case. I have done it many times for the relief of dysenteric affections, where these have arisen from impure water. Such are facts.

We have reason to be satisfied that the provision made for the health of the seaman, in his physical relations, is continually improving. So

long as we steadily push those measures which stand boldly out, as demanding our attention and adoption, we have a most promising future. Earnestness in this matter is only evinced by an ever present intelligent watchfulness. According to Sir Gilbert Blane, the mortality of the British Navy in 1772, was one death for every forty-two of mean strength. It rose steadily from this figure to 1813, when it was one for every one hundred and forty-three of mean strength, and has been continually improving upon this, up to the present time, if we deduct the wounds and accidents.

In the United States Navy for the years 1873 and 1874, there was one death for every two hundred and twenty-three mean strength.

The comforts and conveniences which are arranged and dedicated to the retirement, repose and sleep of the seaman, the varied good or bad influences affecting his character and the government to which he is subjected, will briefly conclude this paper.

Perhaps there are none of the vital-forces which exert a more benign influence upon the individual in the ship, than the light of day. There are those among the seamen in the ship (I use the term in the sense indicated at the beginning of this paper) who are well known, and unmistakably recognized on account of suffering from the exclusion of light. These persons become so accustomed to the absence of sun light, that they avoid it and seldom come on deck until after daylight has disappeared. The evident remedy for such cases is compulsory exposure to sun-light and change of duties, temporarily.

It is not proposed to seek reformation for the accommodation of men or increased comforts where such change is impossible, nor is it proposed to secure in a ship the appointments of a house on shore. But the provision which can be made for more light, and benches and tables for the use of the men, where they may eat and read or write, with some of the comforts of civilized human beings, is not a change which has not already been made with acknowledged satisfaction.

Artificial light, while contributing to the comfort of men below, possesses no other sanitary value, and detereorates the air. With the improved methods of ventilation, there can be no objection to artificial light on this score. While, as all know, the products of combustion escape more readily, if lamps and candles are placed beneath an open hatch, yet practically, who ever went a cruise and found any comfort in using a lamp or candle situated thus? The first shower breaks all the lamp chimneys, when the lamps are lighted, and a few times exhausts all the chimneys in the ship. The wind-sail passing down the

same hatch, where the lamp is usually hung, finishes up both chimneys and lamps frequently. The only escape from these calamities is mechanical ventilation, so as to carry off products of both combustion and respiration.

There is nothing which adds more to the health and comfort of the seaman than the shellac which is used on the decks.

There is one change which I believe would add much to the comfort of men and the neatness of the deck, which is, to substitute lockers, in which to *insert* the clothes bag, instead of suspending these unsightly bags to occupy air space and obstruct its circulation. In addition to lockers for bags, lockers may also be substituted for mess chests. These things, like a system of ventilation, can only be properly introduced by receiving that due attention which their importance demands, in being incorporated in the original plans of construction, and not in a plan of repairs.

The "heads," now used in our ships, should be substituted by water closets, or a head, if you choose to continue the name, beneath the forecastle. In doing this, however, we would only be following a most perfect system which has been adopted in the English Navy. I have fully described those now in use in the English Navy in my Report to the Bureau of Medicine and Surgery in 1877. It is no less than barbarous to see men in inclement weather endeavor to get into the head, perhaps bathed in perspiration, out of a warm hammock, and becoming saturated with water before returning, obliged to sleep in wet clothing all night. This can be remedied and should be. I also described in the above report to the Bureau, the bathing tub of large dimensions, arranged under the forecastle. With such an arrangement for the comfort of the men, the paper and oakum do not find their way to almost every part of the ship, when she happens at anchor, lying head to wind.

There are some thoughts I would like to offer regarding the present ration, its preservation and the mode of cooking it, particularly of preparing the tea and coffee. A wide field is open here to provide a ration better adapted, more nutritious and more palatable, by employing tin more generally in putting it up. But as the ration is fixed by law and any innovation upon the domain of salt, is regarded with disfavor, I will only mention that by representation of facts regarding *butter*, to the present intelligent Paymaster General, the Navy is now provided with butter which is put up in hermetically sealed tins. The U. S. Army has also adopted the same plan. I have eaten butter put

up this way which was perfectly sweet when three years old. I believe the best of cheese and hominy could be preserved almost indefinitely in the same way. In the matter of rations we ought to lead the world, in the Navy, if we are a little behind in some other respects.

The present and remote rewards which are contingent upon the faithful service of the seaman in the Navy hold out the strongest inducement to him for preserving his health and morals, in spite of environments which often offer unfavorable conditions for achieving high qualifications in these particulars. All will agree that reformation in the Navy began when by the earnest efforts of a few officers, and notably by Rear Admiral Foote, the spirit ration, and all spirits were abolished in the ships of the service. The moral improvement was evident. Ships are no longer obliged to be placed under sailing orders a week, that officers and crew may get sober enough to take the ship to sea. The facts have demonstrated that brandy is not the water of life (*eau-de vie*), and in place of imparting health, life, and strength, it does exactly the contrary. There is no disputing this fact, and it may be done without incurring, what to many is an unpleasant reproach, the name of Temperance Apostle, or Radical Reformer. Not a few officers of the service believe that intemperance should be treated as a disease. This would be impossible without extending to the victim the privilege of at any time disregarding the difference between right and wrong. These cases seldom come under the charge of the physician until the irresponsibility consequent upon indulgence assumes a type of mania.

The moral and intellectual character of the man-of-war sailor, is now making marked advances through the teaching and example of his first years in the service, in the training ships. All the elements which ever formed the undesirable part of the sailor's character of other days, are in these ships carefully removed, if found, or denied admission in the beginning. In the apprentice ship *Sabine* to which I was attached in 1865 and '66 we found now and then a boy whose associations on shore had been of a debasing character, and the influence of such boys was distinctly marked in the associates they formed, and in their conduct record. They certainly made no better sailors for having been associated with ignorance, crime and debauchery. This education of the minds and morals of the sailor in the English Navy, says Thomas Brassy, M. P., has produced men of a high order, who after a few years of service in vessels of war, are found in the commercial marine. Many of them are employed, on account of their

steady and reliable character, in steamers, and are eagerly sought for yachtsmen. Nearly all of them are found in England and where the best wages are paid.

There are no efforts spared, but the success is varied, in my experience in the Navy, to make the ship a comfortable and desirable home for the seaman. A cheerful obedience is found to be the characteristic of a happy ship. Insubordination sometimes becomes epidemic, like suicide, and requires prompt repression. In the same way enthusiasm begets enthusiasm.

The present efforts to exalt the moral and mental condition of the sailor, will not fail to increase his self respect. It will, as surely as the day follows the night, encourage patriotism, cause a full appreciation of all efforts made to improve his physical condition, and make him no less willing and ready to place his life in jeopardy, if necessary, a dozen times in an hour, without a thought of having done more than his duty.

This paper is already too long. We have much to congratulate ourselves for on account of what has been done for the seamen, and even more on account of the earnest disposition to do more, as the necessities of the case demand, or the improvement in the morals and intelligence will warrant. There is no place where a statement of facts can be more fitly made than here. Whether there are beauties or deformities belonging to us let them here be held up for inspection. To realize our erroneous teachings, or erroneous prejudices, or that we have no opinions at all, is certainly the first step to knowledge, If in the foregoing there are evils or abuses found, the bare exhibition of them should be enough. I trust it may never be said of the Navy what the Duke of Gloster (King Richard III,) said of his own deformity.

> " Dogs bark at me as I halt by them;
> Why I, in this weak piping time of peace,
> Have no delight to pass away the time;
> Unless to spy my shadows in the sun,
> And descant on my own deformity."

# THE RECORD

OF THE

# UNITED STATES NAVAL INSTITUTE.

NAVAL ACADEMY, ANNAPOLIS,

MAY 8, 1879.

Lieut. Commander W. M. FOLGER, U. S. N., in the Chair.


## TESTING WATER ON BOARD SHIP.


BY LIEUT. COMMANDER HORACE ELMER, U. S. N.


MR. CHAIRMAN AND GENTLEMEN:

There are few things of more importance to the health of a community than good water, and of all classes of people sailors are certainly most sorely tried in that respect. They are compelled to drink water in all parts of the world, and even if they escape absolutely bad water, they must suffer the results of constant change. On board of our men-of-war these evils are partially avoided by a free use of the distilling apparatus; but such use is expensive, and in hot climates, getting up steam for that purpose, not only adds greatly to the discomfort of all on board, but increases the suffering of the sick. Frequently this additional suffering and discomfort might be avoided and coal economized if there were any reliable means on board ship for testing the purity of shore water. At present there are no adequate means furnished for making such tests. In a pamphlet issued from the Naval Laboratory at New York, entitled "Memoranda to accompany the Naval Test Case," a sufficiently complete and satisfactory method is given for obtaining the degree of hardness as well as the chlorides in waters, but the test suggested for organic matter is the old one of dropping a solution of potassium permanganate into the water until the pink color becomes permanent, and in that form is too crude and incomplete to be of any practical value. It is true that the use of potassium permanganate in water analysis has been advocated by many distinguished chemists, notably by Drs. Miller, Woods and Letheby, and very recently Dr. C. Meymott Tidy, in a paper published in the Journal of the Chemical So-

ciety, January 1879, describes a process depending upon the action of potassium permanganate upon organic matter in waters, which he calls the "oxygen process." Without however the numerous and delicate precautions embodied by him in this process the use of potassium permanganate as a test of the organic purity of water is of no value, but is worse than useless if any reliance be placed upon it. In fact, however, no reliance is placed upon it, and our surgeons, appreciating the inadequacy of the means placed at their disposal for testing water, almost invariably recommend, on all stations within the tropics, that no water shall be taken from shore. Under the circumstances such a rule is the only safe one, and yet it is in just these parts of the world, the heat and discomfort of distilling are most felt. But aside from its very great importance in these climates in enabling the surgeon to discover and approve good water, a more accurate water test will be of even greater advantage in other parts of the world in detecting bad water, where the general healthfulness of the climate may have tended to lull suspicion.

The impracticability of setting up a working laboratory on board ship or the complex apparatus for ordinary water analysis is apparent to every one; hence, though the want has been felt by all, little effort has been made to supply it. It would seem, however, that for the new system of water analysis which has recently come into common use, a simple and compact apparatus might be designed suitable for ship board. A plan for such an apparatus, or rather, the suggestion of a plan, for it is by no means complete, I desire to propose to the members of the Institute this evening.

In complete water analysis, the amount and character of the solid contents must be accurately ascertained. On board ship this sort of careful work cannot be done, and fortunately for our purposes, it is not necessary. The great danger is from organic impurity, and water may be sufficiently impure from the presence of organic matter to cause dysentery, typhoid fever and other diseases, and yet be perfectly clear to the eye and pleasant to the taste. Hence, the detection of organic impurities is of the first importance.

While connected with the department of chemistry and explosives at the Torpedo Station, Captain K. R. Breese, then in command, called the attention of Mr. Hill, the chemist of the station, and myself, to the possibility of designing some convenient and simple apparatus for testing water on board ship. The pressure of Mr. Hill's other duties and my own subsequent detachment prevented our giving the subject the

attention I could have wished, but I trust I may be able to make the practicability of some plan, either ours or one of a similar character, sufficiently clear to awaken an interest in the subject.

There are three different methods common among chemists for determining the organic matter in water, viz., the ammonia, combustion and oxygen processes. Of these the first, on account of its ease, simplicity, and rapidity, seemed best adapted to the purpose we had in view, which was not an accurate quantitative analysis of the water, but simply a speedy method of judging of its wholesomeness. Hence our efforts were confined to adapting this method for use on ship board with as little labor and as simple and economical apparatus as possible.

The combustion process, commonly called after its inventor, Dr. Frankland, requires an accurate and careful analysis of the water residue after evaporation. This demands a considerable time, special and elaborate apparatus, and great skill in manipulation, and for these reasons, aside from all others, it is impracticable on board ship, where none of the ordinary facilities of a laboratory for delicate work can be expected. The oxygen process, as previously stated, is based upon and is a refinement of the old potassium permanganate method, and though it is possible it might be adapted to use on board ship, it has not yet had sufficient trial by different chemists to warrant its adoption, and it certainly demands more time as well as more delicacy of manipulation than the ammonia process of Wanklyn. This consists, in the words of Wanklyn himself, " in the measurement of the nitrogenous organic matter in waters, by the quantities of ammonia yielded by the destruction of the organic matter." The quantity of ammonia is indicated by the Nessler test. The process requires, 1st, the distillation of the water by itself, and 2nd, its distillation with potassium permanganate and caustic potash in excess. The ammonia produced from the first distillation is called " free ammonia," and is rather " an indication of past contamination" : that from the second distillation is called "albuminoid ammonia," and in any appreciable quantity, indicates the actual presence of dangerous organic matter. This process does not require an extensive apparatus or numerous reagents, nor any of the usual laboratory facilities for ignition, drying, weighing, filtering, etc., neither is it necessary that the operator should be an expert chemist. The combustion and oxygen processes are distinctly *chemist's* processes, while by Wanklyn's method, any intelligent person, having a fair knowledge of the general principles of chemistry, and his reagents all prepared, can, with very little practice, make a determination

with sufficient nicety for all ordinary purposes. Still, simple as it is, the ordinary apparatus is too large for use on shipboard, nor would it be convenient to provide a sufficient amount of water for a Liebig condenser.

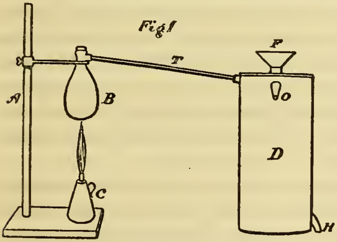
Before describing the compact apparatus suggested for this purpose, I may, perhaps, be excused for giving a brief outline of the Wanklyn process. (See Water Analysis, Wanklyn, for full particulars.)

A half litre of water is used. This is poured into a clean glass retort, whose beak fits into the tube of a Liebig condenser, to which a supply of water is generally carried by rubber tubing from the sink. The flame of a Bunsen lamp or gas burner being applied to the retort, the water soon begins to boil and distil over. The distillate is collected in glass cylinders marked at 50 c. c. (cubic centimetres) each and reserved for the Nessler test. This consists in dropping 2 c. c. of the Nessler reagent into each 50 c. c. of the distillate. If there is any ammonia present the liquid will assume a brown color, varying in depth according to the amount of ammonia present. The amount of ammonia is found by taking a clean cylinder and dropping into it a certain measured quantity of a standard solution of ammonia, and filling up the cylinder to the 50 c.c. mark with pure distilled water. This is then treated in the same manner with the Nessler reagent and the two cylinders are then placed side by side on a white surface, and their colors compared. This process is continued, with varying quantities of the standard solution, until the imitation is perfect. In practice, the first 50 c. c. is Nesslerised for the free ammonia, and the next 150 c. c. thrown away, experience having shown that they always contain just one third of the amount shown in the first 50 c. c. The distillation is then stopped and 50 c. c. of a solution of potash and potassium permanganate added, after which the distillation is continued, and the succeeding three 50 c. c. of distillate carefully Nesslerised, to obtain the amount of albuminoid ammonia. The standard solution of ammonia is so arranged that each cubic centimetre will represent one part to the million where one litre of water is used, consequently, as the amount of water actually used is but half a litre, the results obtained by the first and second distillations are doubled to obtain the number of parts to the million or milligrammes to the litre. Where these show more than fifteen parts of albuminoid ammonia to the million, the water should be rejected. It will be perceived there are no weighings nor tedious dryings and careful ignitions in this process. The calculations are already made and the test consists simply in the care-

ful comparison of colors, and with a little practice, this can be readily done. Many objections have been urged to this method from a scientific standpoint, partly induced, perhaps, by the inordinate claims made for it by some of its advocates, but even its opponents acknowledge that its indications are valuable, while denying the precision of its results.

It may not enable us to say, exactly, how much organic nitrogen there is in the water, but it will enable us to judge, for all practical purposes, whether it be wholesome or not, and that is all we desire. From its ease, convenience, and simplicity it would appear decidedly the most practicable method on board ship, It does not displace any other method: it takes the place, virtually, of nothing. Consequently its adoption does not seem to involve any discussion of its merits compared with those of the other two methods I have mentioned. On this subject the most distinguished experts differ and a most excited controversy has been carried on among them for some time past. This is consequently ground upon which I do not care to tread.

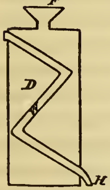
Fig. 1




SHIP APPARATUS, SET UP FOR USE.
A Retort holder. B Retort.
C Spirit Lamp. D Condenser.
F Funnel. H Delivery.
O Overflow. T Glass Tubing.

To shorten the Wanklyn process and simplify the necessary apparatus, it is proposed by Mr. Hill to use but 50 c. c. of water. This would require but a small retort; a flask capable of holding 100 c. c. with oval bottom, glass stopper and outlet tube at the neck (see B fig. 1) would probably be the most convenient; this to be held by an ordinary retort holder about fifteen inches high. A spirit lamp will supply the necessary heat. The condenser may be a flask with a glass worm, such as is sometimes made for laboratory use, or as I would prefer, a small copper condenser with a flat, silver lined, angular worm (w fig. 2.) This form of condenser, with a tin lined worm has been patented for the use of druggists, is very small, not much larger than a quart measure, but I have seen it in operation and it does its work rapidly and perfectly. For our purpose it would be better to have the worm

Fig. 2




Condenser. (*Section.*)
W Flat, angular worm.
F Funnel. H Delivery.

silver lined, and the plating could be done at very little extra cost over the ordinary tin lining. The small amount of sea water necessary for condensing can be supplied through the funnel by an attendant. The Nessler reagent, ammonia and potash solutions should be carefully prepared at the Medical Laboratory, bottled, and put on board ship with the medicinal stores. With the small amount of water used, the quantities of these required would be very much reduced. A four ounce bottle of the Nessler reagent and a litre of each of the other solutions would seem amply sufficient for a cruise. Should the Nessler reagent become exhausted or need renewal, all the necessary materials for preparing it will be found among the ordinary medical stores. If preferred, the Nessler reagent could be put up in separate bulbs, similar to those containing sulphuric acid in the Harvey bolts, each bulb holding the exact amount to be used at one time, that is, about .2 or .25 c.c. of the reagent. This would avoid the necessity of making such small measurements with the pipette.

In addition the following apparatus would be necessary :—

Six (6) small glass cylinders, marked at 5 c. c. each. One (1) graduated burette, to measure the standard solution of ammonia, and a small number of glass rods and tubes. Most of these will be found in the Naval Test Case and the remainder can be added to it without much additional cost and very little increase of size. The most expensive feature of the apparatus is the condenser, and that will cost about five or six dollars.

It will not, of course be necessary to make an organic determination of all water received on board ship, but only when taking it for the first time in any given port, or where there is reason to suspect the character of the shore water, nor will it be necessary, each time, to measure the exact quantity of organic impurity. If the application of the Nessler reagent to the first distillate gives a decided brown color, it will be sufficient to warrant the rejection of the water without continuing the process, as no water, bearing the slightest suspicion of present or past contamination should be received on board ship. The extreme care and exactness required in the examination of water for a permanent supply, do not enter into the question here. If the water from one well or cistern is not perfectly satisfactory, it can easily be procured from another, if that is still unsatisfactory, the distilling apparatus always remains as a last resort. There is therefore no reason why water having the slightest taint of suspicion should be received.

This, as you will readily perceive, simplifies very much the task of the examiner.

The time required for such an examination would be small. I have made a careful determination, by the Wanklyn process, using a half litre of water, in about two hours, including the time required to set up the apparatus. With 50 c. c. of water and the ship apparatus, it ought not to take more than three quarters of an hour, and for the incomplete tests, which would be all that would be necessary with positively bad water, twenty minutes ought to be sufficient. The pure water required for the purpose of comparison should be previously distilled with the same apparatus from very pure spring water, if possible, and kept in bottles for use when required.

The organic impurity of water is of the first importance, and with a satisfactory test for that, one may rest content; still, it sometimes happens that organically pure water will contain such a large quantity of dissolved and suspended matter, as to be unfit for cooking and drinking purposes. This is the case with very hard water. It is a thumb rule that the total solids should not exceed forty grains to the gallon, and, should it be desired, this total amount could be very easily obtained, (though somewhat roughly, perhaps,) by carefully evaporating 70 c. c. of the water in a porcelain or platinum dish, which had been previously weighed, and then reweighing the dish and residue after evaporation, the difference in weight in milligrammes being the number of grains of solid contents to the gallon. This is, of course, common practice, and I merely suggest it as a simple additional test, requiring no apparatus excepting a small water bath, an evaporating dish and the apothecary's scales. In itself, it is, of course, of little importance compared with the previous tests for organic impurity, still the process of evaporation may give some valuable indications as to the organic condition of the water, as most impure waters on evaporation to dryness, give off an offensive odor, and it seems to me the Surgeon should have the apparatus for making this examination, should he consider it necessary.

I have not had the opportunity of talking with many Naval Surgeons on this subject, but those with whom I have talked, not only coincided with me as to the necessity of some more perfect water test, but expressed their belief in the practicability of the Wanklyn process on board ship, and the convenience of the apparatus I have described.

NOTE.

Since writing the foregoing, I have had the opportunity, at the laboratory of the Torpedo Station, of trying some experiments with the oxygen process, as described by Dr. Tidy. The results were fairly satisfactory, but upon trial, the method does not appear to me any better adapted to use on shipboard than it did on first reading. It requires for a determination, at least, four hours, and I do not see how the time can be reduced.

H. E.

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Passed-Ass't Surgeon CORWIN. I consider the plan proposed by the lecturer, for testing water, to be a step in advance of anything we now possess, and think there is no doubt as to its feasibility on ship board, the only objection being the time necessary for the determination. Time is here a matter of great importance. When the tests are to be made the medical officer is generally hurried, the water boat often coming alongside when the stores are coming in, and the decision is quickly required. I think at least an hour would be needed to do it properly. There could be a great saving of time however, if a standard of color were selected for comparison. For instance, a solution of potash bichromate or other coloring matter in 50 c. c. distilled water, of such strength that it should equal in depth of color that produced by a dangerous proportion of free or albuminoid ammonia with Nessler solution in the same bulk of liquid. The strength of such a color standard could quickly be ascertained by experiment and it could then be kept on hand, or prepared in a moment when wanted.

Two test tubes of equal size should be filled, one with the color standard, and the second with the Nesslerised distillate. When the latter *equals* or *exceeds* in depth of color, the standard, the water must be rejected, when *lighter* in shade it may be accepted. This procedure may be objected to as not scientific, but there is no reason why the examiner, after passing upon the question of accepting or rejecting the water, should not be required to continue the experiment to the exact determination of organic impurity and keep a record of the results.

A good light is very necessary to distinguish the differences in intensity of color upon which the determination depends. It seems to me that the process is desirable and can be utilized; the reagents are simple and easily prepared. and it would prove an exceedingly useful method.

Prof. MUNROE. The service is under great obligations to Lt. Comdr. ELMER for seeking to introduce into use Wanklyn's method. It is now well known to water analysts and among the many methods that have been devised and suggested during the last few years in which so much attention has been given by analysts and hygienists to the contaminations in potable water this method has met with the greatest favor and is quite extensively used. I can speak from personal experience as to the accuracy with which it will reveal the presence of ammonia and albuminoids in water and the ease with which it may be employed, as I have frequently used it in the examination of potable water. It must be borne in mind that this process does not supplant those now used by the medical officers; it merely supplements them. The total solids and chlorides must be determined as before; so the examination will occupy a longer time than heretofore. There is one objection that is urged against the Wanklyn process. It is said to prove too much and to condemn some waters which contain vegetable albuminoids which are not dangerous to health. This however is a point for the doctors to settle; the chemist simply proves the presence or absence of

the albuminoidal substances. It is unfortunate for the service when a harmless natural water is condemned; for although there may be a plentiful supply of distilled water for use it is not so valuable as the natural water, since the latter contains certain salts and gases in solution which render it more palatable and which no doubt play a useful part in the animal economy. We try to reach this result by aerating our distilled water and I understand that in the Russian service they have issued a saline mixture to be added to the distilled water. It seems to me that it would assist our medical officers in deciding as to fitness of a water if they were directed to examine the source of the supply. They could then judge of the liability to contamination and whether the organic impurities were such as would prove dangerous to health. It would in many cases render an examination unnecessary by revealing the presence of stables etc. near the source of supply.

Passed-Ass't Surgeon CORWIN. It certainly is advantageous to examine the source of supply, but it is not always practicable.

Passed-Ass't Eng. KAFER. It is a case in point to mention that since the China fleet suffered so severely from cholera, none but distilled water has been used on board the ships, and with beneficial results.

Passed-Ass't Eng. MANNING. The water which was extensively used in the North Atlantic Blockading Squadron, and which was generally preferred, was Juniper water from the Dismal Swamp. This would certainly have been condemned by this process, as it contained a great deal of vegetable matter, but it really was not objectionable.

Passed-Ass't Surgeon CORWIN. I can understand that organic matter may exist in water, but, at the same time, its injurious effect be neutralized by the presence of some other principles, as in the case of the Juniper water.

THE CHAIRMAN. I think the lecturer has taken a good step in bringing to notice this process and in making experiments to demonstrate the possibility of its use on board ship. From my experience as Executive Officer, I must agree with Dr. Corwin, that in a great many cases, it will take too much time. When the water boat comes along side, and the water must be taken in without delay, as frequently happens, it would take too long. In such a case the ordinary tests for salts would have to be used. With regard to examining the source, in those parts of the world not frequently visited by men-of-war, it would be an excellent idea, but at the ports most frequently visited the character of the water is generally pretty well known. I think the subject worthy of serious consideration, and I am sure all will agree with me in returning thanks to the lecturer for the pains he has taken in developing a very useful subject.

# THE RECORD

OF THE

# UNITED STATES NAVAL INSTITUTE.

U. S. NAVAL ACADEMY, ANNAPOLIS,

MAY 8, 1879.

Passed Assistant Engineer J. C. KAFER, U. S. N., in the Chair.

In the absence of the author, P. A. Engineer MANNING read the following paper on

## THE U. S. SHIP TRENTON.

### (A Supplement.)

BY GEO. W. BAIRD, PASSED ASSISTANT ENGINEER, U. S. N.

As there had been no full speed trial of the *Trenton* at the time I wrote my paper describing the improved machinery on board that vessel, and in consequence of the discussion that followed, I am induced to offer this, a supplementary article.

The trial trip occurred in the Mediterranean on the 15th day of October last, when there was no wind blowing nor any motion of the sea to influence the vessel's speed.

| | | |
|---|---|---|
| Duration of the trial, in hours | | 6.00 |
| Maximum speed in geographical miles per hour | | 14.00 |
| Mean speed in geographical miles per hour, per log line | | 12.63 |
| Mean speed in geographical miles per hour, per observation | | 12.83 |
| Mean pressure of steam, in the boilers, in lbs. per sq. inch, above the atmosphere | | 70.00 |
| Mean pressure in the receiver, in lbs. per sq. inch, above zero | | 21.845 |
| Maximum number of revolutions of the engines per minute | | 61.00 |
| Mean number of revolutions per minute | | 54.46 |
| Mean vacuum in the condensers in inches of mercury | | 20.17 |
| Mean number of holes of the throttle-valve open | | 8.00 |
| Mean number of inches followed by the pistons at the time the steam was cut off | High pressure | 28.7 |
| | Low pressure | 30.00 |
| Mean draught of water in feet and inches | Forward | 18-5 |
| | Aft | 20-8 |
| Mean number of pounds of coal consumed per hour | | 5744.37 |
| Maximum horses-power developed by the engines | | 3100. |
| Mean number of horses-power developed by the engines | | 2813.11 |
| Mean number of pounds of coal per indicated horse-power per hour | | 2.042 |
| Temperature of the atmosphere, in degrees Fahrenheit | | 74. |
| Temperature of the sea-water admitted to the condensers | | 74. |

| | |
|---|---|
| Temperature of the sea-water discharged from the condensers | 119. |
| Temperature of the feed-water discharged from the condensers | 137. |
| Temperature of the engine-room | 96. |
| Temperature of the fire-room | 157. |
| Temperature of the coal bunkers | 111. |

It was found that coal could not be brought from the bunkers as fast as it could be burned. It will be remembered that there is no forward bunker on board the *Trenton*, and that all the coal is carried behind and above the boilers. There is one door on each side, aft of the boilers, through which the fuel is brought, but the railway does not extend into the bunkers. The Engineers on board believe there would be no difficulty in sustaining three thousand horses power if the coal could be supplied.

## The Windlass.

As this machine was selected, in preference to a steam capstan, designed by myself, I passed lightly over the faults, in my former paper. The faults of the windlass are only in detail and can be easily corrected.

*Fig. 1*

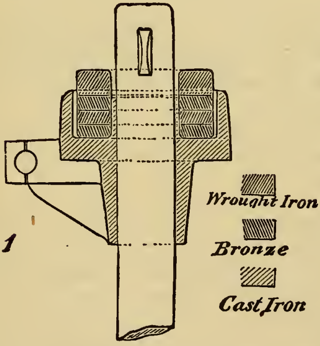



Fig. 1 is a vertical section of the head of the worm shaft, with its thrust bearing. It has two collars of wrought iron and two of bronze, all of which are loose, excepting the top one, which is slotted to carry the key, and revolves with the shaft. The aggregate bearing surface of this device would be sufficient if the collars were arranged as in ordinary practice; but as it is, the thrust is against the upper collar and is transmitted through the others, leaving the pressure per square inch of surface the same as if there were but one collar, and with heavy heaves, the pressure is sufficient to force the lubricant out. There has never, to my knowledge, been any lack of power in the engine of the windlass to bring up or break out the anchors, notwithstanding the acute angle the chain forms in passing the hawse pipe. Mr. Sickles informed me, personally, that he had considered that in the design, and had sufficient power in

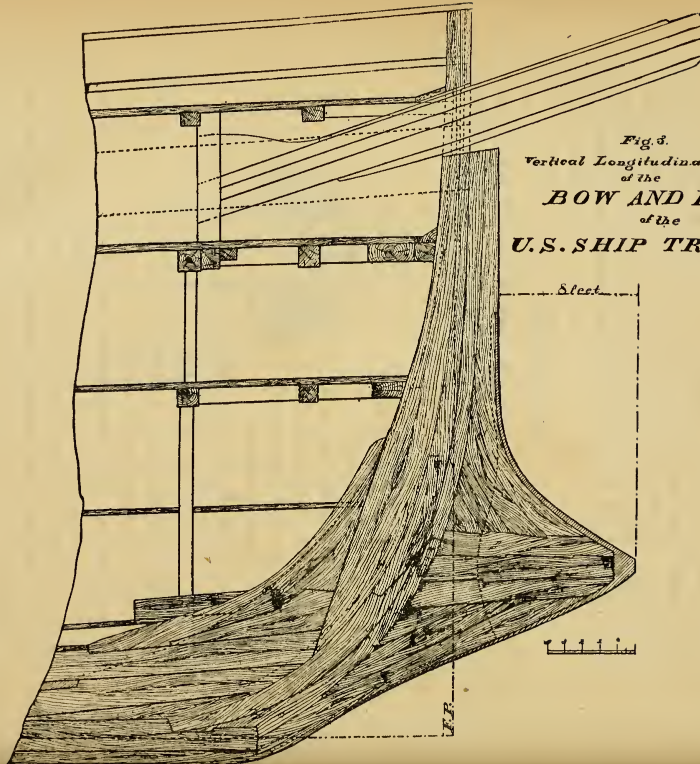



Fig. 3.
Vertical Longitudinal Section
of the
BOW AND RAM
of the
U.S. SHIP TRENTON.

the engine to bring up two anchors at a time, for which the windlass is arranged.

I found that by smoothing the surfaces of the collars, and by holding the top one central, by filling the annular space with hard wood—as it sometimes moved from the center—the bearing worked very much better, and I do not think it has been hot since; but to permanently overcome this trouble I design a roller thrust as shown in Fig. 2, which I hope to see built.

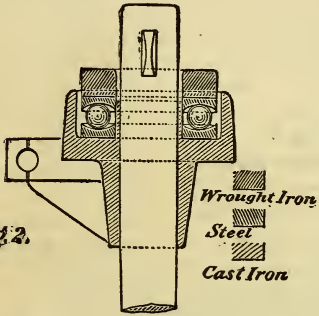



Fig. 2.

I would like very much to have the views of some of the gentlemen present on the merits of windlasses as compared with capstans for war vessels. The first cost is very much in favor of the capstan, while the windlass presents a corresponding advantage in handiness. The capstan is very much lighter than the windlass and as there is room for many more men to work at the bars, the anchor can be raised in less time by the capstan than by the windlass, while the question of deck room, so valuable on board ships of war, presents another reason for preference for a capstan. I regret that I have not a copy of the design for the proposed capstan for the *Trenton*, but will give a similar plan further on.

### The Bow and Ram.

I offer in Fig. 3, a drawing of the bow and ram of the *Trenton*, which will make my former description more intelligible. It is really a ram of hard wood covered by a thick bronze casting, and is so designed that the vessel would not leak badly if it were broken off. Longitudinally it is immensely strong, but laterally it is not. As the length of the ram is not great, the danger of breaking it off, even under aggravated circumstances, is not great.

### The Steering Engine.

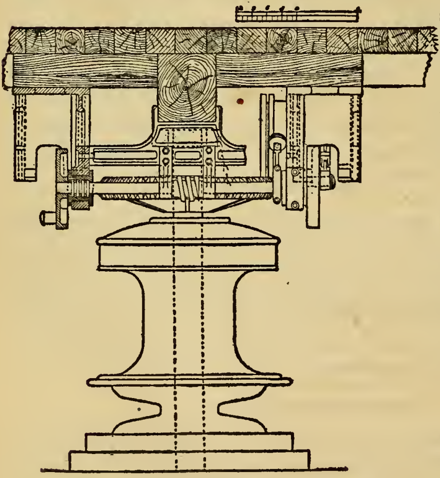
I wish here to correct an error in my former paper, in which I stated that this engine could not be made to work smoothly. At that time the machine had never moved the rudder, when the vessel was in

motion, and, therefore, no opportunity had been offered for experiment, but since that time the machine has been put in use, and it was found by Assistant Engineer Mattice (a graduate of the Academy) that, by reducing the pressure upon the pistons—by means of Mr. Sickles' automatic valve—the engine was made to work very smoothly.

### The Design for a Steam Capstan.

The design for a steam capstan was not preferred by the Chief Constructor of the Navy—who at that time had charge of that matter—for the reason that it was to be worked on the main deck, which he wished to be kept clear, forward, for bow guns. The engine was designed to be bolted to the spar deck beams, under that deck, and directly above the capstan itself. It was essentially the same as that shown in Fig. 4, which design I have recently finished for the *Vandalia*

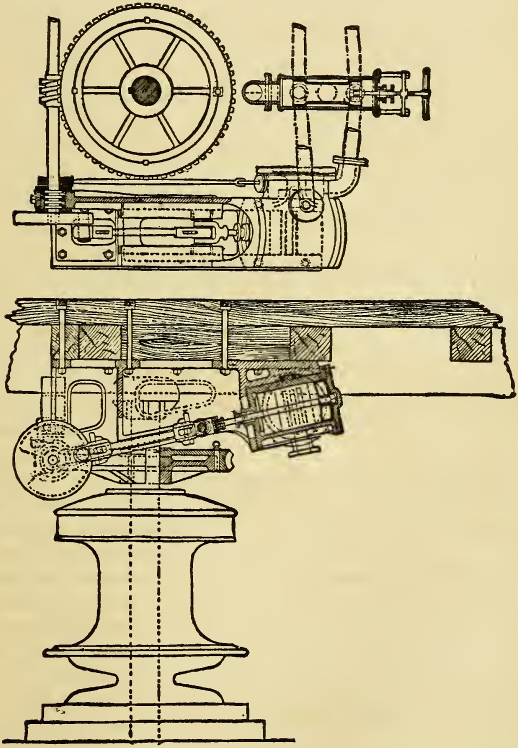
Fig. 8.
CAPSTAN ENGINE
Designed for the
U.S. Steamer Vandalia.
by
George W. Baird
Engineer Corps U.S. Navy



In this it will be seen that the spindle is prolonged, and carries a spiral gear, which is worked by the engines. The spur-wheel is not made fast to the spindle, but envelopes another wheel, which is keyed, and the two wheels are united by a small key, shown near the periphery. To disconnect the steam gear, in order to work by hand, this small key or pin is removed.

The engines are reversed by means of a piston valve which is placed between them which changes the ports. This method necessitates the steam to follow full

stroke, but gives the advantage of dispensing with water valves, which so simplifies the machine that skilled labor is not necessary for running it. A system of permanent leading blocks carries cords to the barrel of the capstan in order to cat and fish the anchor.



# THE RECORD

OF THE

# UNITED STATES NAVAL INSTITUTE.


NAVY DEPARTMENT, WASHINGTON,
MAY 29, 1879.

Professor SIMON NEWCOMB, U. S. N., in the Chair.

## USES OF ASTRONOMY.


BY REAR ADMIRAL JOHN RODGERS, U. S. NAVY,
SUPERINTENDENT NAVAL OBSERVATORY.


In some occupations it happens that the good attained by them is not seen at once, but only when the effects are traced to their sources do we find the meaning of the work. Sowing wheat, for instance, seems at first waste of grain; traced further, it is found that the operation feeds nations.

This is true of astronomy: more curious at first sight than useful, the observations duly recorded and tabulated, have made the civilization of the world what it now is.

Greenwich Observatory is a foundation upon which England's commerce is built. Heroism, skill, devotion, could do little without tools to work with; and without Nautical Almanac and sextant, commerce could never have reached its present importance.

Commerce carries abroad religion, civilizes cannibal isles, exchanges the products of labor, takes abroad the things which are not needed at home, and in their stead brings articles of necessity, of convenience, or of taste. Commerce breaks down the barriers of prejudice which separate nations; and these prejudices subdued, it attacks the physical obstacles which stand in its way. It cuts down hills, and fills up valleys; it tunnels mountains, and bridges rivers; it builds harbors, and for its peaceful and beneficent purposes creates all the facilities which make it so immense in its proportions, and so powerful a means of spreading community of interest, and hence tolerance and good feeling amongst nations.

The work of Observatories blends so intimately with modern navigation, that no cargo can be exported nor brought home except through its agency. No wheat, no cotton, no tobacco, can be exported except under the safeguard of astronomy. No books come from abroad except under the protection of astronomy. No traveler risks his life upon the ocean without the tutelage of astronomy. No missionary of religion, or of science, or of useful knowledge, ventures to leave his own shores except with the help of astronomy.

All this, to one who does not at once admit what I have said, seems like mere rhetoric, and it may be worth while to find out, as well as we may, the real money value of this science.

Before astronomy lent its aid to navigation, the freight and insurance charges were enormous. It is known that old voyages were long, tedious, dangerous; that the vessel instead of sailing directly to her port, crept along the land, groped her way through shoals, skirted the coasts, and painfully, like a blind man, felt her way along shore with lead and look-out, never knowing exactly where she was; never knowing how dangers not in sight bore from her position; not knowing exactly where her port was upon the earth, relatively to other ports.

If the difficulties, and dangers, and duration of voyages, were inordinate, the profits were also inordinate; and if the insurer asked huge premiums, the insured could, out of his high gains, well afford to pay them.

In Shakspeare's Tempest we read—

> "There were such men
> Whose heads stood in their breasts; which now we find
> Each putter-out of five for one will bring us
> Good warrant of."

This refers to the custom which obtained with travelers going into distant lands, of putting out money to be returned five for one, when the traveller should come back to claim his pledge. If he did not return, the whole sum belonged to the lender.

In this sentence Shakspeare makes the insurance five for one; but let us suppose it only one for one above the present rate, and let us see the gain to the United States, in a single year, from the uses of astronomy as applied to navigation.

The imports into the United States in 1877 were, in part,—sugar, $ 90,683,826; coffee, $ 53,634,991; tea, $ 16,181,467; and the *total* imports amounted to $ 492,097,540. Exports for the same year were, in part,—cotton, $ 181,403,415; wheat, $ 69,308,119; tobacco, $ 32,

312,529; the *total* exports, $658,637,457. Thus it will be seen that the ocean commerce of the United States alone, amounted to the sum of $1,150,735,087, in a single year; and if the entire commerce of the maritime nations be considered, the aggregate value will dazzle the imagination.

I have estimated that the rate of insurance would, without the aid of astronomy, be only one for one, or on our whole exports and imports, $1,150,735,087 This sum now actually saved to the country, would, if applied to the purpose, in two years pay our whole national debt.

This result is so stupendous that, beyond the sublime, it seems to reach the ridiculous. Men smile at something so far beyond their received opinions. But it is to be remembered that all astronomy is to be invoked to give the present results.

Columbus had some kind of astronomical tables, or, as we should call them, some kind of Nautical Almanac; for he had means of measuring roughly the sun's altitude, and of deducing the latitude from his observations. Such tables had existed long before the time of Columbus.

The solution of the problem of differences of longitude was attempted in early times, dating even from the time of the ancient Egyptians; but the results obtained were very inaccurate. The first comparatively accurate theoretical solution of the problem may be said to date from the discovery by Galileo of Jupiter's satellites and his tables of their motions. In practical accuracy, Galileo's tables were worthless.

While the theory of this method is perfect, its practice is even now far from being so, since the power of the telescope, and the clearness of the night, come in as quantities not readily estimated.

The tables used before Greenwich Observatory was established, were those of Tycho Brahe or of Kepler, which were so erroneous that their use would entail an error in the resulting longitude of some 900 miles.

It is not to be wondered at that charts were erroneous. A shoal or island 900 miles out of position would be hard to find.

Navigation is now so precise that a vessel may start from New York for Australia, and, seeing no land until off her port, run boldly for the harbor, sure of her position in relation to it.

In my own experience, when I first went to China, we were boarded about 6 o'clock in the morning by a pilot, who immediately upon coming on deck changed the course some three points to the westward.

I said, pointing to the direction we had been steering, Hong Kong is *there.* "No," said the pilot, "it is *there,*" persisting in his opinion. I concluded he might have just lost sight of the land and that the "John Hancock" might have drifted a few miles to the westward at night. I acquiesced.

We made the land in a little more than an hour, and then the pilot hauled the vessel up to the course she had been steering before he came on board, I remarked to him—" I was right, you see, in saying how to steer for Hong Kong." "Oh," said he, "you have been to Hong Kong before." When I said, "no I never was in Hong Kong," evidently he did not believe me, and the fact must have seemed miraculous or false. A man who never was in Hong Kong comes from America and points to the direction of the Island he has never seen, more accurately than a pilot who has just left it! In such a case, one could more readily attribute falsehood than accept a miracle.

I have not spoken of the intellectual uses of astronomy; of how, as it reveals to the imagination and to demonstration the infinite expanse of creation, it enlarges the scope of men's faculties, and heightening their comprehension of the Creator, brings them into closer communion with Him.

I have referred only to the prosaic money value of observatories. Without these, the antipodes could not have become familiar channels of traffic. The throng of travel and the burden of commerce could never have risen to their present greatness. Civilization would have been much slower in its diffusion. Colonization would have been deferred and retarded in its march. Without observatories, steam, as applied to navigation, would have lost much of its value, since, as direct voyages could not be made for lack of accurate charts, and from the uncertainty in the navigator's position, a ship load of coal would not have sufficed for a long voyage.

The Naval Observatory, when requested, takes observations upon stars used by the surveying parties of the government, in order to fix the latitude of certain points. These stars are frequently, and perhaps generally, those not near the best explored parts of the heavens, and are therefore those whose place for nice modern work, is not known with all desirable accuracy. In finding the latitude by Talcott's method, pairs of stars are selected, each one as nearly as possible equidistant from the zenith, and respectively north and south of it, and not far apart in right-ascension. So many conditions attach to the proper selection of pairs, that any star which suits in position and magnitude

must be taken as one of a pair; and if, as too often happens, the star's place is not exactly known, the Observatory fixes it, and furnishes the positions to the surveyor, who is thus enabled to determine his latitude with the utmost precision. Without these observations, the geodesy of the country would be more tedious and less exact than it now is.

It thus appears that the public land sales are dependent upon the determination of the boundary meridians and parallels, in which work the Naval Observatory is an efficient and active coadjutor.

The work of Lieut.-Commander F. M. Green, assisted by Lieut.-Commander C. H. Davis, in fixing the longitude of places in the southern part of Europe, and in South America, is very useful, as giving a greater precision than has heretofore been reached in regard to places, not only where the observations are taken, but to all others dependent on the first as prime meridians.

To this work, so useful to the commerce and geography of the world, the Naval Observatory contributes its part, first by giving time-signals to England, thus enabling our longitude to be carried to Lisbon, Rio de Janeiro, Bahia, Pernambuco, &c.; and next by star observations for zenith telescope work.

The English have less faith in telegraphic longitudes than ourselves; and thus we have, so far, been pretty much alone in this field, in which we have attained valuable results.

The Coast Survey has need of special observations, which can only be made in a fixed Observatory, where instruments of the largest size and of the greatest exactness are employed.

We have given star determinations to Lieutenant Wheeler, of the U. S. Engineers, employed in exploring and mapping the regions of the far west.

Miscellaneous stars, observed with the Meridian Instruments of the Observatory, for the use of other scientific departments of the government.

| | |
|---|---|
| For Army Engineers | 548 |
| " Coast Survey | 588 |
| " Lt. Comd'r F. M. Green | 232 |
| " Transit-of-Venus Commission | 101 |
| Total | 1469 |

The observations of these stars have been nearly completed, except about two hundred for the Coast Survey; but the whole number of different observations will average about three for each star, making

about four thousand four hundred observations. To these should be added the number of observations of clock stars, circumpolar stars for azimuth, and the nadir observations which are necessary to the reduction of the work—fully six hundred; makiug five thousand observations in all.

To do this work properly, would require, at least, *four* trained observers and computers, and two extra computers, one entire year to prepare the results.

All the extra work here enumerated has been performed within ten years, indicating that one-tenth of the labor of three-fourths of the working force of the Observatory has been devoted to the direct assistance of other departments.

The Naval Observatory has also assisted in the determination of the longitude of the following stations, the observations of thirty different nights being devoted to this work in 1877 alone.

At the request of the U. S. Coast Survey:

Cambridge, Mass.; Island of St. Pierre; Savannah, Ga.; Key West, Fla.; St. Louis, Mo.; Columbus, Ohio; Nashville, Tenn.; Harrisburgh, Penn.; and for the boundary line between New York and Pennsylvania; Hale's Eddy, N. Y.; Wellsburgh, N. Y.; and Great Bend Village, Penn.

For Army Engineers:

Austin and Carlin, Nevada; Detroit, Michigan; and Ogden, Utah.

At the request of the Directory, the Observatories at Lehigh University, Bethlehem, Penn.; and at Princeton, New Jersey.

It is thus seen that the Naval Observatory is really national in its scope of labor, as well as international by its coöperation in nautical astronomy.

Prof. NEWCOMB. I would like to ask one or two questions which the paper just read by the Admiral, brought to my mind. Did not Prof. Airy, at one time, make a calculation of the money value of each observation of the moon? I have an idea that I have seen a statement that he did so, and fixed the amount, but I have never heard anything authoritative on the subject. Perhaps the Admiral could enlighten us on this point?

Rear-Admiral RODGERS. You would know about that better than I.

Prof. NEWCOMB. Perhaps some other gentleman knows whether he made such a calculation, and whether I am right in my impression?

Lieut. SCHROEDER. I have heard the same, somewhere, but cannot now recall it.

Rear-Admiral ALMY. The name of Prof. AIRY brings to my mind some incidents, very interesting, which I think are closely connected with the subject of Naval Observatories. I recollect, that many years ago, I was ordered to the Depot of Charts and Instruments, located on Capitol Hill in 1842. The Government had rented a lot of ground, and two rooms in the house, from Lieut. WILKES, who owned the property, and had put upon it a small building for protecting and working the Transit Instrument. There was a small three or four inch Transit Instrument mounted; also, a small three or four inch Telescope, and under the charge of Lieut. JAMES M. GILLIS, who was, at that time, very deeply interested in his work, and most indefatigable in his observations. A series of Magnetic Observations was also being conducted.

I do not know whether it has a history or record of its observations as a Naval Observatory, now in possession of the Government, or not; but I am sure it left a history as a Government Nautical Observatory.

Lieut. JAMES M. GILLIS generally had several young officers associated with him in his labors, and had matters so arranged that by one relieving another, a regular watch was kept, and in this way the observations were almost continuous. I recollect very well on one occasion Mr. A. A. LOW, of New York, a prominent and intelligent East Indian Merchant, and at that time President of the Chamber of Commerce of New York, came to the Observatory at the time I happened to be on duty there, and he remarked that he had just come from England, where he had visited the Greenwich Observatory, in which he felt a great interest; that he had there met Prof. AIRY, who at that time was connected with the Greenwich Observatory, and until Prof. AIRY had told him, he had no idea that there was such a thing as as an Observatory in Washington. He told us that the Professor gave him much iuformation concerning the observations taken in Washington, but Mr. LOW, not willing to admit his ignorance on the subject, did not care to say much. The Professor told him that some very valuable observations had been sent him by Lieut. GILLIS, which proved of great service to him, and he spoke of this little observatory we had in Washington in most complimentary terms, and he also spoke in high terms of Lieut. GILLIS who had sent him such a large number of valuable observations taken here.

It was in 1842 that I became attached to this little observatory. The appropriation of $50,000 was made by Congress about that time to erect what was then called a "Depot of Charts and Instruments" to be located where it is now. This was the beginning of the present U. S. Naval Observatory and most of the gentlemen present here to-night know the result. I must say it is pleasant to me to recall these incidents and I think it of interest to all Naval Officers to take part in these observations.

In the Summer of 1842, Captain WILKES returned from his Exploring Expedition, and required the use of the two rooms and the ground, for his own particular work, which involved the necessity of moving.

The Navy Department rented a large double house which had a good sized yard and garden, known as the "Forsyth House," located on the south side

of Pennsylvania Avenue, near 24th Street, N. W., and nearly opposite to the Columbia Hospital. This had been the residence of the Hon. JOHN FORSYTH when Secretary of State in the administration of President VAN BUREN.

To this place the Charts, Chronometers, Magnetic Instruments, and the all-important Meridian Transit, and the little Telescope were removed, and good service performed for two years under the superintendence of Lieut. M. F. MAURY, U. S. N., assisted by a corps of young Naval Officers.

About the time of removal from Capitol Hill to the "Forsyth House," Lieut. GILLIS was detached and ordered to Europe to select and purchase the necessary Instruments for the new Observatory and then returned to superintend the erection of the buildings. In due course of time the Instruments arrived—were mounted and adjusted, and in the Autumn of 1844, full possession taken, and work commenced in the building known as the U. S. Naval Observatory. This has continued ever since with most creditable and useful results, conferring honor on the country and distinction upon its several Superintendents and Officers associated with it.

One thing I shall say in regard to Naval Observatories, and it is this, that officers who waste a great deal of time aboard ship and at stations, always apply themselves and become quite industrious when they arrive at an Observatory. I know it has been my own experience. It has always proved very interesting to me, for there is something about it which is highly attractive and instructive.

I had made a cruise at sea, during which time this Observatory had been constructed and the instruments set in place, and upon my return I was ordered there. I remained about fourteen months and during that time, I must say, that I performed very laborious duty. Lieut. Sands was there then. I well remember that we had to sit up all night every other night, and many a morning I did not get home until day was breaking. Still I became very much interested as also did the other officers. There were four of us in one room, each seated at his desk in a separate corner, and we have worked for hours together without saying anything whatever. So intently were we engaged in our work, that we never thought of conversing.

At that time the present Admiral of the Navy, (PORTER) took very great interest in this institution. He had charge of the Equatorial and made many inventions from time to time in connection with it. He made many splendid drawings of the heavenly bodies, and until then I had no idea that he could draw so well. I mention this fact to show the amount of interest we all manifested in these observations and the improvements that followed one another.

Prof. NEWCOMB. I think it is generally believed that Admiral ALMY was one of the first officers engaged in marking longitude by telegraph. It is thirty odd years since this was first done, and as there are so few now living who assisted in this matter it would be very interesting indeed if the Admiral would be kind enough to tell us how it was done in the beginning.

Rear Admiral ALMY. It would not take long to tell just how we did it, and I shall do so with great pleasure. Prof. WALKER, known to most of the scientific gentlemen of the day, and the public generally, as the publisher of "Walker's Almanac," was appointed to the Observatory at the time when Mr. BANCROFT, then Secretary of the Navy, took such a great interest in this matter. Correspondence was then opened with persons at Baltimore, where a small observatory was located, at the time, to assist in the undertaking. When we had arrangements completed, Prof. WALKER and myself worked one transit instrument together all night. I recollect that he asked my opinion on the subject, and talked frequently about it, and I remember very well the interest I felt in it; and spoke of what a grand thing it was. I told him I was only too glad to coöperate with him. We, however, got to work, I taking the transit observation, he marking the time. The telegraph had then been brought to the Observatory, for the first time, and as the stars passed the meridian I would notify him when he would mark it down and telegraph it, whilst they were marking down the observ-

ations and telegraphing them in Baltimore. Thus it was that the longitude between Washington and Baltimore was first correctly ascertained and it proved very successful. I believe that I took the first transit observations that were ever taken to establish the difference of longitude by telegraph. I do not know that any one had previously made observations in that way. This was performed in the year 1846. I think a full account of this achievement was published in "Walker's Almanac." I tried to ascertain if there was anything on record or an account of observations taken at that time, but was unable to find anything.

Prof. NEWCOMB. The Chronograph was not in use then, I believe?

Rear Admiral ALMY. No sir; it was not.

Rear Admiral RODGERS. How did you arrange the transit observation? Did you touch the wire when the star passed and Prof. WALKER touch the telegraph?

Rear Admiral ALMY. Yes sir. And I think the reason that there is no record of these observations is, that at that time there was no publication touching upon this subject.

Prof. NEWCOMB. The Admiral has spoken in his paper of some means that Columbus had for ascertaining the difference of longitude by the stars. I do not know whether the incident is authoritative, but it is said that Columbus on one occasion, when troubled by the natives, told them that if they did not behave themselves better the moon would disappear, and on the night following there was an eclipse of the moon. Now Columbus must have had some means for ascertaining this fact, or else it was quite an opportune occurrence.

Rear Admiral RODGERS. He certainly had some table for ascertaining that fact.

Prof. NEWCOMB. I suppose there was an Almanac at that time, supposing this incident to be an established fact.

Not quite connected with the subject of the paper read before us to-night, but remotely connected with it, is a circumstance that will, perhaps, interest every one here to-night. I understand to-day that Prof. STINGER, Director of the Russian Observatory has concluded to come over here this summer to examine the great telescope at the Observatory, the object being to have one manufactured that shall surpass it. The Russian Government has already voted an appropriation of two hundred and fifty thousand roubles for the purchase of a telescope, and negotiations are now being carried on with different makers for its construction. They have not yet concluded who shall do the work, but their idea is to have one party do a portion of the work and another do the other part. The polishing of the glass, which is the most difficult part of all, is not yet definitely settled, but they are inclined to have it done in Munich; yet before final arrangements are made, the Professor, after coming to Washington, will go from here to Cambridge and see what sort of a bargain he can make with Clark and Sons.

Prof. HARKNESS. It is exceedingly gratifying to see gentlemen, occupying such high positions in the Navy, looking back with pleasure to the period before the war, when they were connected with the Naval Observatory. During the War, Naval officers were engaged with other things, and in order to carry on the work of the Naval Observatory, many civilians had to be employed. There was plenty of money for such purposes then, but now economy is the order of the day, and once more naval officers take their places at the Observatory. Some of the gentlemen say they like the work; that it is interesting and attractive to them; while others assert that there is a certain routine to learn, and after that is known, and the methods of observing are acquired, the same operations are repeated day after day. The whole work of the world is done just in that way, and yet I do not see any other mode of accomplishing it. An officer, navigating a vessel every day over the same course, gets only a certain amount of knowledge; and yet there was a time in the life of the most eminent man of the age, when

he worked just in that manner, going over the same ground day after day. The men who spend months upon algebraical and arithmetical operations, and think they are learning nothing, find subsequently, when they are surveying or navigating a ship, and strike upon problems outside the ordinary routine, that they have gained a vast amount of information which they could not have acquired if they had not gone over elementary principles so often. They discover that when they encounter difficulties under different circumstances, without being in a position to have access to books, this knowledge is of the utmost value. In that way the Naval Observatory may confer great benefits upon the Navy, and the Naval officers stationed there will obtain instruction that cannot fail to advance them in their own profession.

In the present age fighting is becoming a science. What chance would a navy, fighting in the old fashioned way, stand with one availing itself of all the appliances of modern science? Take one of Nelson's ships, for instance, commanded by Nelson's officers, and put her into a fight with our modern vessels, and the result could not be doubtful,—the old fashioned ship of the line would surely go to the bottom. Scientific instruction is of the utmost importance, and I repeat, that I am greatly gratified to see officers, old in the Navy, recalling, with pleasure, the incidents of their youthful service in the Naval Observatory, and I hope that we younger officers will also look back in later years in the same manner.

Lieut. LONGNECKER. I would ask Admiral ALMY if there was ever a history written of the Observatory from its original foundation up to recent years? I have looked around for such a history, but have been unable to find it.

Rear Admiral ALMY. I am not aware that there is such a book in existence. I think it would make a very interesting paper and this discussion may have a tendency to bring about such a matter.

Rear Admiral RODGERS. I think we have one at the Observatory. It is put in the form of an appendix in one of the volumes containing observations for the year 1875.

Lieut. LONGNECKER. But what I refer to is a history of the Observatory, the founders, appropriations and how gotten through and by whom, details of the progress of the Institution. I have seen the pamphlet referred to by the Admiral, issued as an appendix of the volume of 1875 containing observations made in that year, but when I say a history I mean the details in connection with the institution from its foundation, how it originated, etc.

Rear Admiral ALMY. I think it originated about the time Capt. GILLIS was in charge himself. It occurs to me that there is a Congressional volume containing the first report. After Lieut. GILLIS had completed his work of erecting the Observatory, mounting the Instruments &c., &c., he made a report, which was a very interesting one. It contained a history of the appropriations made from time to time, his visit to Europe, the selecting of instruments, how they were constructed, what they cost, how mounted and in fact everything connected with that part of the institution. He made the report to the Secretary of the Navy and a call was then made on Congress for it. Accordingly a certain number of copies were ordered to be published and I suppose there are copies on file in Congress now.

Lieut. LONGNECKER. I think it would be a good idea to buy a copy of that kind and place it with the other books we now have in our possession for the use of the Institute. It certainly should be in our collection.

Rear Admiral ALMY. I think I have this volume; I know I did have it. I now recall a very interesting event connected with the mounting of the instruments and the purchasing thereof. Lieut. GILLIS deserved a great deal of credit for everything connected with his work. I know myself he had to work very hard to get the appropriation through. The instruments he purchased at the time were excellent ones in those days and we made great progress with them in our labors. He mounted them all successfully, I think, except the Nautical circle. I know that he used sulphur in

the cement and it had the effect of blacking everything and consequently the instrument could not be kept clear or clean. But finally another cement was used and it was mounted perfectly. After that it worked well. I just mention this as one of the little incidents connected with this matter.

On motion of Lieut. Longnecker, the Chairman tendered the thanks of the Institute to Rear Admiral Rodgers, for his interesting paper.

# THE RECORD

OF THE

# UNITED STATES NAVAL INSTITUTE.

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Rear Admiral G. B. BALCH, U. S. N., (Vice President,) in the Chair.

## THE WAR IN SOUTH AMERICA.

By LIEUT. J. F. MEIGS, U. S. N.

The war now being waged in South America between Chili on the one side and Peru and Bolivia on the other is of interest to naval officers because of the importance of the part which the navies of the two nations play. The belligerents are separated by the Desert of Atacama, an arid waste of two hundred or two hundred and fifty miles width in a north and south direction, which is without water or animal life, and over which it would be difficult, if not impossible, to transport an army. The sea, if commanded by either belligerent, offers, on the other hand, a safe and easy means of transporting armies and supplies.

The force in men and material of the two navies, for Bolivia, having no merchant marine and few ports, has no navy, may be ascertained by reference to statistical books on the subject. I have prepared, from data obtained by Lieutenant R. P. Rogers, a table of the force of the ships engaged in the fight at Iquique, on May 21st, and I have the pleasure of forwarding this table herewith. It is well to state here, also, that neither the Peruvian nor the Chilian navy has had much actual sea service. It has been the custom of the Chilian government to send a vessel from time to time to the straits of Magellan; and, within the past two years, the Almirante Cochrane, the sister ship of the Blanco Encalada (or Valparaiso, as she was first called,) has been to England under the command of her present captain. The Peruvian officers have had even less opportunity to perfect themselves in their profession. With the exception of an occasional trip of the Union or

Pilcomayo to Panama, the ships of the Peruvian service have not been at sea.

Thus neither service is much better off than the other in sea service. The Chilian officers, though, are generally more carefully educated than their adversaries. Many of them have been instructed in the special schools of England; and they show, in conversation, a knowledge of the implements of naval warfare, and the theory of their use, which is far ahead of that possessed by the Peruvian officers.

The cause of the existing war is briefly as follows: The territory between the parallels of 23° and 24°, with what inland limit I am unaware, was, until 1866, a part of Chili. In that year it was ceded to Bolivia, certain stipulations concerning the revenue derived from the ceded territory being agreed to. In 1874, there being some difference between the two nations as to the execution of the old treaty, a new one was made. This treaty was no better observed than the first; and, the discovery of valuable deposits of nitrate of soda in the neighborhood of Antofagasta having made the disputed territory a source of considerable revenue to its possessor, the two nations became involved in retaliatory measures which ended in the occupation of the territory in question by a Chilian army in the early part of the current year. It is due, however, to Chili to say that she was moderate, until forced to violent measures; while Bolivia's course was, throughout, marked by the violence of a semi-civilized nation.

There had existed between Peru and Bolivia a secret treaty which pledged the assistance of the former in certain specified cases. Whether any of the cases existed or not remains an open question; but, from the time when Chili first assumed a hostile attitude towards Bolivia, Peru began preparations for war on sea and land, and permitted the transportation of troops and war stores of the Bolivians across her territory. Negotiations were at once opened between Peru and Chili; and, the latter being unable to obtain any guarantee of neutrality, declared war against Peru in the early part of last April.

Peru, it may fairly be concluded, seriously meant to assist Bolivia. Her interests are deeply involved in the issue of the struggle. The great value of the nitrate deposits at and about Antofagasta will enable the Chilian merchants who own them to compete in the market with the Peruvian government, which owns nearly all the nitrate and guano deposits in the country. The competition, too, will probably result to the great advantage of the Chilians, as they work the mines by private companies, whereas the Peruvians have made a government

monopoly of theirs. This would be entire ruin to Peru, as nearly all her revenue is derived from the shipment of guano and nitrate.

At the time when the war was declared, the Chilian fleet, under the command of Admiral Williams Rebolledo, had been at sea, engaged in transportation service and the guarding of the army lines of supplies for about three months. The fleet consisted of the sister ironclads Blanco Encalada (flagship), and Almirante Cochrane, the corvettes Esmeralda, Magellanes, O'Higgins, Chacabuco, and the gunboat Covadonga. The ironclads were in good condition and fit for any service; of the corvettes, the Magellanes was the only one whose boilers were efficient. The preparation of the Peruvian fleet was less advanced. All the vessels were in Callao still, and the Huascar was the only one fit to move.

A Chilian army of occupation was quartered in Antofagasta, and at other places in the disputed territory. The Bolivians, under their president, General Hilarion Daya, were at Tacna and Arica; and the Peruvian army were at the same places and at Iquique.

The early measures of the Chilian fleet along the coast of Peru were prompt and well judged. On April 5th, Admiral Williams appeared off Iquique, the town from which nearly all the Peruvian nitrate is shipped, and declared the port blockaded; warning all neutral vessels to desist at once all operations of loading and unloading, and ordering them to quit the port within ten days, upon pain of detention. On the 15th and 16th of the same month, a part of the Chilian fleet went to Huanillos and Pabellon de Pica, a day's run south of Iquique; and fired upon and destroyed the chutes, platforms, and other machinery for loading guano.

Thus, in ten days after the declaration of war, Chili had cut off her enemy's revenue, the expenses of Peru being paid almost entirely from money received for the guano and nitrate shipped to foreign countries. The property destroyed was largely English and German; but, as Peru received a sum down immediately upon the shipment of each cargo, it appears that Chili did not go beyond her just belligerent rights.

It must have been shortly after the events just recorded that a plan of attack against the fleet in Callao was prepared by Admiral Williams. The attack was to be made at night, and it was desired that the moon should be in a certain quarter. As everything could not be got ready in the month of April, the attempt was abandoned until the following month. Meanwhile, the Peruvians were landing troops at

Pisagua, about forty miles north of Iquique; and were sending them, together with provisions and supplies necessary for a long time, into the last named place.

The Chilians did not blockade Pisagua. They contented themselves with going off the port from time to time; and, on one occasion, when the troops quartered there fired upon their boats, which were destroying the launches in the harbor, they fired upon the town and burnt a large part of it. The neglect to blockade this port was a great mistake on the part of Chili. It is only one hundred and thirty miles south of Arica, the headquarters of the allied Peruvian and Bolivian armies; and, from it, by the railroad to the nitrate deposits, it is easy to send troops to Iquique, or to send supplies for those already there. To those who are not, perhaps, altogether well-informed upon the matter, it appears that the Peruvian army of four thousand men in Iquique in the beginning of April must have been starved out, or driven to great straits, before this time, if Pisagua had been closely blockaded.

An attempt to carry out the plan of Admiral Williams, which has already been referred to, was made in May. On the night of the 21st and 22nd of May, the Chilian fleet, consisting of the two ironclads and four corvettes, appeared off the harbor of Callao. One of the corvettes, the Abtao, had been bought within a short time, and she was filled with kerosene and other combustibles. No watch was kept by the Peruvian vessels. They all lay at their anchors in Callao, with no other demonstration of alertness than that they kept their ensigns flying all night. Boats from the Chilian vessels were lowered, and pulled well into the harbor; easily recognizing the positions of each one of the enemy's fleet. But, to their chagrin, they found the Huascar and the Independencia gone. It had been Admiral Williams' plan to run the Abtao alongside the Huascar, set fire to her, and then, by the light of the conflagration, attack the rest of the fleet with his rams and guns.

There is every reason to believe that the plan would have succeeded. The Peruvian ships had, at the beginning of the war, lost the greater part of their crews, which were largely Chilian; the loss had not been made up; and two, or more, of the ships were unable to move because parts of their machinery were on shore.

When day broke, on the 21st, the Chilian fleet was seen in line of battle, with their heads to the south, off Callao. The excitement in that city and in Lima was intense; the shore batteries were manned, merchant vessels moved out of the range of the guns, and the Peruvian vessels sought places of safety under the forts. But Admiral Williams,

probably unwilling to risk his fleet under the fire of the heavy guns on shore, for the chance of destroying the old, broken-down monitors and wooden vessels, moved off to the south with his fleet, at noon.

The Huascar and Independencia, in company with the transport Oroya, carrying General Prado, the President of Peru and the Commander-in-Chief of her armies, had left Callao bay on the 16th. These vessels presently reached Arica, and, hearing there of the absence of the ironclads from before Iquique, though not knowing their whereabouts, determined to attack the two wooden vessels blockading Iquique. Accordingly, the Huascar and Independencia, under the command of Captain Grau, commanding in person the Huascar, sailed from Arica on the night of May 20th. After touching at Pisagua during the night, to make sure that their information was correct, they appeared off Iquique at daylight on the morning of the 21st.

The Covadonga, a wooden gunboat of about four hundred tons, was outside, and reported immediately to her consort, the senior ship, that the enemy's ironclads were in sight. Captain Prat signalled the Covadonga to take her position in his wake, and these two little vessels prepared for fight. It was doubtless the purpose of Captain Prat, from the first, to fight, though the disparity of force was so great. He could not escape, because his vessel, as appears from Señor Uribe's report, could not steam more than two or three knots, while the Independencia's speed was twelve knots, and the Huascar's perhaps eleven. The Covadonga could probably have steamed seven knots.

At eight o'clock A. M., the Huascar fired a shot, which struck between the two Chilian vessels, and the action immediately became general; the Huascar singling out the Esmeralda, and the Independencia the Covadonga. After the firing had been going on for about an hour, at distances varying from two thousand yards to perhaps one thousand, the Covadonga steered to the south, the Independencia following her closely.

The Esmeralda remained in Iquique harbor, fighting the Huascar. By this time the Peruvian soldiers had dragged a field battery down on the beach, and had begun to fire at the heroic little vessel, at distances not exceeding four or five hundred yards. Thus, with the three hundred-pounders of the Huascar on one side, and a field battery on the other, the Esmeralda was forced to quit the position near the shore, which she had taken to avoid a ram attack from the enemy, and go further out in the bay. The time when this occurred, and the time when the Huascar first rammed, I have been unable to fix satisfactorily;

but it could not have been far from half past ten, two hours and a half after the beginning of the fight. It appears that Captain Grau was detered from ramming by the fear of torpedoes, which he supposed were placed around the Esmeralda ; and he rammed only when the latter vessel was driven from the place which she had first occupied, by the fire of the field battery on shore. The defence of the Chilian vessel would have lasted a much longer time than it did, if the fight had been decided entirely by the guns. The Huascar kept up a fire from all her guns for four hours, and, during this time must have fired at least forty shots from her two three hundred pounders; yet we have record of only one of these shots which struck the enemy. This shot passed through the side, burst in the engine-room, and killed every one of the engineers.

The reply of the Esmeralda was most effective, as is testified by Captain Grau ; but musketry and forty-pound shots are no match for seven-inch armor. Captain Grau is in error when he speaks of the mitrailleuse fire of the Chilians; neither the Esmeralda nor the Covadonga had machine-guns of any kind. The Huascar had one large gatling, if not more; and the Independencia had, probably, some kind of machine-guns.

When the Esmeralda came out in the bay Captain Grau determined to ram her. In the first attempt, the Huascar, steaming about eight knots and steering N E., struck the Esmeralda, nearly motionless and heading N., on the port quarter. The Huascar's engine was stopped when she was about one ship's length from her adversary. The blow was harmless. Captain Prat, followed by one man only, gallantly sprang on the forecastle, and, sword in hand, rushed aft on the port side of the deck, and was killed by a musket ball at the foot of the turret. The command of the ship now devolved on Lieutenant Serrano. The Huascar backed off, and made at the Esmeralda again, this time steering south ; the Chilian vessel presented her bow ; the Huascar's engines were stopped too soon, and she struck the starward bow of her enemy, doing little or no damage. Again a boarding party, headed by the commanding officer, Lieutenant Serrano, leaped on the Huascar's deck; but only to be shot down. The third attempt of the Huascar was better conducted. The head of the Chilian vessel had fallen off to W., and Captain Grau, steering S., going full ten knots and stopping his engines when twenty feet from the Esmeralda, struck his adversary squarely on the starboard beam. The Esmeralda sank with her colors flying and guns firing.

Surely there never was a better fought action. The heroic courage and devotion of the Chilian sailors may serve as an example to all navies. When we examine the preparations, and consider the conduct of these men, we can hardly find anything that could be better. It is evident that they hoped great things from boarding, but the shortness of the enemy's contacts prevented any great number of men from getting on board. Nevertheless there were not wanting officers of sufficient daring to try what could be done in this way. The particulars of the ram-attacks, I may here state, are as given by Captain Grau, in conversation with Rear-Admiral Rodgers.

The Covadonga, meanwhile, was doing all that seamanship and courage could do to get away from her huge pursuer. She led along close to the shore, crossing shoal places, and actually, at times, almost in the breakers. The Independencia, with her raw, unskilled gunners could not hit the little craft, though the vessels must have been within two hundred yards of each other several times. Captain More fearing that he could never end the affair with his guns, determined to ram; this he tried three times, and failed to accomplish. His third attempt was made off Punta Grueso, at a time when the Covadonga was not one hundred yards from the beach. Steering about S S E., the Independencia aimed an oblique blow at the Covadonga's starboard quarter, and, missing her enemy, struck a rock, and stuck fast. It appears, from the reports of both Captains More and Condell, that the helm of the Peruvian ship was not ported in time at the critical moment to avoid her going ashore, because a lucky shot from one of the Covadonga's seventy-pounders killed her helmsman. The only wheel of the Independencia was the ordinary one, on deck; the Huascar had a fighting wheel, which was under the little iron lookout tower of the captain; the latter is a few feet aft of the turret.

It must have been about 11.45 A. M., when the Independencia struck. Captain Condell, seeing at once the state of affairs, turned his vessel, and, passing along the starboard side of the enemy, coolly took his position astern of him and began to fire. The Independencia, after what interval I have been unable to ascertain, hauled down her flag, and hoisted a flag of truce, as, indeed, she was obliged to do; for the enemy was deliberately firing into her, and she was unable to return a shot, having fallen over on her starboard side, while all the lower part of the ship was full of water.

Immediately after the surrender of the Independencia, and before she was taken possession of, the Huascar, which, having sunk the Es-

meralda at 12.10 P. M., had remained to pick up the survivors of her crew, came around the western end of the island which forms the south side of Iquique bay. She was about ten miles off, and the Covadonga, having evidently disposed of the Independencia, took to her heels. The Huascar, after speaking her stranded consort, to find out if there was any immediate danger to the life of her crew, resumed her pursuit of the Covadonga. This pursuit was kept up until dark, when Captain Grau, seeing that there was still ten miles between him and the chase, and probably uneasy about the enemy's ironclads, whose position was unknown to him, gave up the pursuit, and returned to the Independencia. This vessel it was clearly impossible to save, and she was set on fire and burned.

The operations of the Huascar after the 21st of May are not of importance. On the 26th, she appeared off Antofagasta, the headquarters of the Chilian army, with the purpose of destroying the fresh water condensers there and of doing any other possible damage. The Chilians had three 150-pdr., Parrotts mounted in the tower, and these, with the two 70-pdrs. of the Covadonga, which had been hauled to a place of safety inside the reefs, drove her off. She received one oblique blow from an elongated projectile below her armor and water-line, which, if it had struck point first, might have caused her loss. On the 30th of May, off Pisagua, she saw the two Chilian ironclads, Blanco Encalada and Almirante Cochrane, and the corvette Magellanes. These vessels chased her to the west and north for seven and a half hours, but were unable to get near enough to use their guns. On the third of June, the Huascar sighted two steamers, and approached within four miles of them before she saw that they were the Blanco and Magellanes. She was chased by these vessels for eighteen hours and they succeeded in getting within four thousand yards of her at one time. Fourteen shots were fired by the Blanco, but none struck; the Huascar fired four times, with no better success. In firing the Chilian ship is said to have used her four forward guns; thus she must have yawed about 20° on one side and the other of her course; and, perhaps, in this way, have allowed the enemy to escape. The Huascar had no solid shot, and, for this reason probably, did not fire oftener. It is stated by her officers that they would have engaged the Chilians if they had had suitable projectiles. On the eighth of June, the Huascar reached Callao, without further incident.

On the 5th of July, she sailed again for Arica, having had her bottom cleaned, and having on board a supply of good coal. Her cruise

on this occasion is instructive, as showing what a veesel which has the advantage in speed may do in the face of a more powerful enemy. She entered Iquique roads on the night of the 9th; but did not find there, as was hoped, the Couseña, or some of the weaker of the Chilian vessels. Captain Grau remained some time in the bay, and communicated with the general in command of the army. As the Huascar was going out at about 3 A. M., she met the Couseña, a slow and old collier used as a transport. She forced this vessel to surrender; but, before she could be taken possession of, the Magellanes and other Chilian vessels were seen. With these the Huascar had a short running fight, and escaped into Arica.

She sailed from this port again on the 17th of July; this time in company with the Union. These two vessels went to Caldera, Chañaral, Cavriyal, Bajo, and Pau de Ayucar—all Chili ports—and destroyed the launches which are used in landing and shipping cargoes. They captured, also, two Chilian merchantmen, loaded with coal and copper. On the 21st, when near Antofagasta, they chased and captured the Chilian transport Rimac. This vessel had been purchased by the Chilian government from the South American Steamship Company at the beginning of the war. She is a new iron screw-steamer, of eighteen hundred tons; and had on board, at the time of her capture, the Yungai battalion of cavalry, consisting of about three hundred men and two hundred and fifty horses.

To complete the narrative of the hostile operations on both sides to the present date, there is only one more event to record. This is the bombardment of the town of Iquique on the night of the 16th of July. It is well known to everyone in Lima, and presumably to the Chilian admiral, that three Lay torpedoes, with their apparatus complete, and an American expert to operate them, have been sent to Iquique. On the night of the 16th the lookouts on board the Blanco, then lying at anchor in Iquique, saw what they supposed were torpedoes. The ironclad opened fire upon these objects; and, immediately afterwards, when the objects had probably disappeared, upon the town of Iquique. Forty-four shots were fired: a number of people, non-combatants and others, were killed, and some property destroyed. The consular corps, acting as a body under the chairmanship of their dean, addressed a letter, the next day, to Admiral Williams, protesting against the bombardment, on the ground that it was an act of barbarism, and was unjustifiable by the modern law of war. To this the Admiral replied that the town was in a state of defence, was garrisoned by some thou-

sands of Peruvian soldiers, had fired upon the Esmeralda when she was engaged with the Huascar, and, finally, that the successful application of the torpedo directed from the town would have caused the death of a large number of persons who were quite as defenceless as the people of Iquique.

With these unimportant results the people of the two countries seem fairly well content. The number of men under arms bears a very large proportion to the population, and the war must eventually end from want of money if something is not done. Chili has some ten or twelve thousand men in and near Antofagasta; Peru and Bolivia have fifteen or sixteen thousand at Arica, Tacna, Pisagua, and Iquique; between the two hostile armies lies the almost impassable desert of Atacama. Under such circumstances it appears not improbable that Chili, if her finances can bear the strain, having now what she took up arms for, may adopt an inactive policy; and may leave Peru to make the aggressive movement.

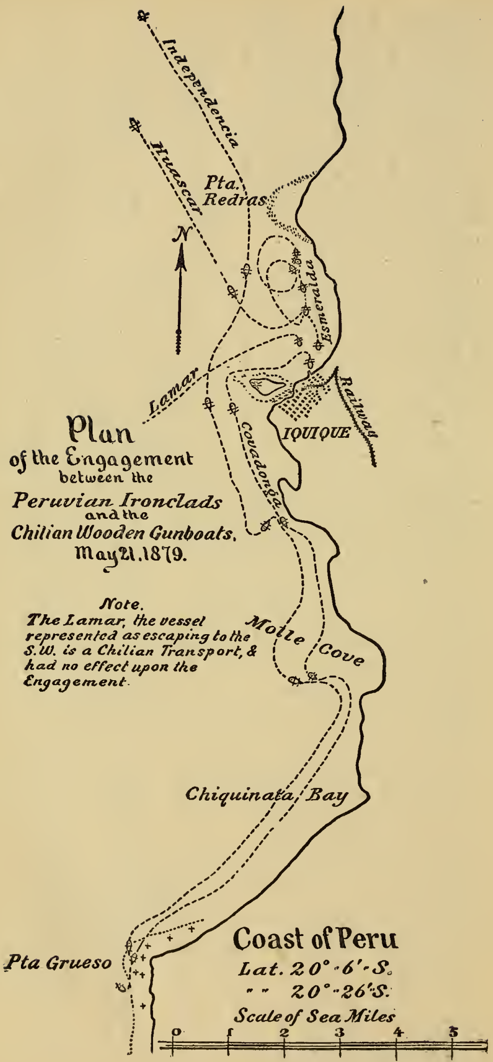
In conclusion, I have to state that the reports of Captains More and Grau, which are appended, were translated by Commander Terry and Lieutenant Mason; the principal outlines of the diagram of the fighting in Iquique harbor are taken from a drawing made by Cadet-Midshipman Smith, under the direction of Captain Breese; the report of Captain Condell, of the Covadonga, and a part of that of Señor Uribe, the senior surviving officer of the Esmeralda, are also appended. I regret that fuller Chilian accounts could not be had; the writer, however, has heard several Chilian officers, and some eye-witnesses to the affair, converse about the details of the fight in Iquique harbor, and believes that, as far as it goes, the recorded account is correct. It will be observed that there is a difference in the reports of Captain Grau and Señor Uribe as to the time when Captain Prat boarded; the report of the Chilian officer has been adhered to in the narrative. The diagram of the ram attacks of the Huascar, and of the fighting in Iquique harbor, is known to be accurate in all points but one. This is the course which the Huascar steered as she returned to the second and third attacks. These are unknown; and as they, in themselves, are not very essential, they have been assumed, the position of the Esmeralda, and the direction of the heads of the two vessels in each one of the three attacks being known.

## DIMENSIONS ET CÆTERA OF SHIPS.

| | Vessel. | | | | | | | Armament. | | | Machinery. | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Draught. | | | | | | | | | | | |
| Name of Ship. | Class. | Material. | Forward. | Aft. | Length between perpendiculars. | Breadth of beam. | Tons displacement. | Number and kind of guns. | Height of battery above water. | Thickness of armor at water line. | Builders. | Indicated horse-power. | Maximum speed in knots per hour. | Remarks. |
| Independencia, | Iron-clad frigate, | Iron, | 21′ 6″ | 22′ 6″ | 215 | 44.75 | 2004 | 2 150 pdr. Armstrong,<br>12 70 " "<br>1 Vavasseur, 250 pdr.<br>1 Parrott, 150 pds. | 10′ 0″ | 4″.5 | John Penn & Sons, | 1500 | 12 | Barque rigged. |
| Huascar, | Monitor, | " | 15 0 | 16 0 | 193 | 35.5 | 1130 | 2 300 pdr. Armstrong,<br>2 40 pdr. Whitworth, | 5 6 | 4.5<br>2.5 | Laird Bros. | 1000 | 11 | Brig rigged. |
| Blanco Encalada, | Box-battery, | " | 18 8 | 19 8 | 210 | 45 9 | 3560 | 6 12½ ton Elswick, | 5′ 6″ | 9.0 | John Penn & Sons, | 2920 | 9 | |
| Esmeralda, | Sloop, | Wood, | 13 0 | 17 0 | | | 854 | 12 40 pdr. Armstrong, | | | Ravenhill & Co. | 400 | 5 | The tons are 6. M. |
| Covadonga, | Gunboat, | " | 12 0 | 13 0 | | | 412 | 2 70 pdr. " | | | Arsenal del Ferrol, | 190 | 7 | |

The *Independencia* was built in Poplan in 1864. The hull is iron and is divided into 3 water-tight compartments. The armor is 4½ inches thick at the water-line, and about the central part of the battery, and is backed by 10 inches of teak. She is built for ramming. Recently one 250 pdr. Vavasseur has been mounted at the bow, and a 150 pdr. Parrott at the stern. Her boilers are new. Her maximum speed on trial on April 27, 1879, was 12 knots. She carries 400 tons of coal.

The *Huascar* carries two 10 inch Armstrongs in a turret of the Coles system; this is moved by hand through gearing. The guns may be fired 10° on either bow, and 32° on either quarter. The turret is 30 feet in diameter; with 7 inches of armor in front of the guns, and 5 inches at the back. The backing is 14 inches of teak. The hull is divided into 5 water-tight sections. It is protected by armor, varying in thickness from 4½ inches in wake of the turret chamber, boilers and engines to 2½ inches at the bow and stern. The backing of teak is 10 inches in thickness. The turret chamber, boilers and engines are protected from raking fire by 4½ inch bulkheads. Her maximum speed is 11 knots. She turns a complete circle in 4 minutes.


Plan
of the Engagement
between the
Peruvian Ironclads
and the
Chilian Wooden Gunboats.
May 21. 1879.
Note.
The Lamar, the vessel represented as escaping to the S.W. is a Chilian Transport, & had no effect upon the Engagement.
Independencia
Huascar
Pta. Redras
N
Esmeralda
Lamar
Railway
IQUIQUE
Covadonga
Molle Cove
Chiquinata Bay
Pta Grueso
Coast of Peru
Lat. 20°·6′·S.
" " 20°·26′S.
Scale of Sea Miles
0 1 2 3 4 5

Report of Captain Grau, commanding the Peruvian ironclad monitor Huascar.

Headquarters of the First Naval Division.
At anchor, Iquique, May 22nd, 1879.

To His Excellency the Director-General of War.

In compliance with verbal instructions received from you I weighed anchor at Arica in the first night watch of the 20th instant, with the monitor Huascar and the frigate Independencia, both vessels belonging to the naval division under my command; and I have the honor to give you an account of the events which have occurred up to this date.

On the passage from Arica to Iquique, I thought it advisable to stand into Pisagua. This I did at 4.20 A. M., of the 21st, in order to enquire for any news relating to the duty which I was to perform at Iquique. I there learned from the captain of the port, who showed me a telegram from the prefect of the department of Larapaca, dated the 19th instant, that the corvette Esmeralda, the gunboat Covadonga, and the transport Lamar, vessels of the Chilian squadron, constituted the blockading force off Iquique.

As we approached Iquique, I saw three steam vessels; and soon could make out among them the Esmeralda and Covadonga. These vessels got under way, and took up defensive positions; while a steamer bearing the United States flag (probably the Lamar,) stood out of the port for the south. The promptness with which she made off, and my then distance of five miles from the port, taken together with the speed necessary to overtake her, decided me to confine my operations to the two vessels first named.

Having arrived, in the Huascar, at about two thousand metres N. W., of the enemy's anchorage, I directed that our colors should be secured, and ordered the Independencia, then approaching from a distance about five miles to the north, to prepare for combat.

The enemy's vessels occupied positions a cable or a cable and a half from the beach, opposite the north end of the town, in order of battle; the Covadonga astern of the other, and both with their heads to the north; so that they were between us and the town. It was 8.20 A. M. of the 21st.

From this time began the fight between the Huascar and the two vessels of the enemy; thirty minutes later, the Independencia joined, and opened fire. Our shot, however, owing to the swell at the entrance to the harbor, could not be well directed; while the aim of the enemy was generally good, both in direction and elevation.

After the first hour, the Covadonga left the harbor, skirting the island which encloses the west [S.W.] part, and attempting to get away along the coast to the south by keeping close to the shore. Seeing this I ordered the Independencia to pursue her; remaining, of course, with the Huascar, to fight the Esmeralda.

Whilst the Independencia pursued her course, observing the uncertainty of my fire, from the cause already mentioned, I decided to attack the Esmeralda with my ram. Having been informed, however, by Commander don Salomè Perras, the captain of the port, and by the pilot of the port, Guillermo Cheele, both of whom had been on board since the beginning of the fight, that the enemy was protected by a line of torpedoes in front of him, I determined to direct my vessel against him by passing between him and the shore by the south, in order to dislodge him from the zone in which he manœuvred. But, seeing that he moved to the north, leaving that zone, I changed my plan, and steered directly for the center of his hull, with a speed of about eight knots. Having accomplished half the distance, I stopped the engine; and the Esmeralda, sheering to avoid a direct blow in her side, received it on her port quarter and in a very oblique direction. The spur glanced; its effect was of little moment; and the vessels remained foul of each other until the Huascar backed off.

I attacked again, with the same speed as before; but the Esmeralda presented her bow, and thus again avoided a direct blow. These two blows, however, had considerably damaged her.

On both occasions, as the vessels approached each other, and while they remained together, we received a continuous fire from the mitrailleuse in the enemy's tops, from small-arms and hand grenades, and broadside discharges from the great guns. The armor well protected the ship and our people from the effects of such a skillful fire, many of the shots of which struck our turret, others penetrating in many parts of the wood and iron. I was enabled to keep up equally well the fire of our great guns and small guns.

Finally, I rammed for the third time, with a speed of ten knots, and succeeded in striking amidships. At this blow the Esmeralda sank and completely disappeared, leaving afloat pieces of her hull and some of her crew. It was now 12.10 P. M.

The Captain of the Esmeralda, together with several of his crew and one of his officers, boarded on our forecastle as she went down, and, in defending ourselves against this attack, they perished, victims to their own intrepidity. I immediately ordered all the boats of the ship to save the drowning; and succeeded in picking up sixty-three, all who survived this obstinate resistance.

I cannot refrain from calling your attention to the sad loss of brevet 2nd Lieutenant don Jorge Velarde, and to the conspicuous gallantry which this officer displayed at his station on deck at the colors; where he fell, a victim to his own coolness and valor.

Having finished rescuing the drowning in the port of Iquique, and with those saved on board, I steered towards Gaueso Point, south of Iquique, intending to aid the Independencia in the capture of the Covadonga. I observed that the latter, when she observed the movements of this ship, stood away with all speed, heading south; while the Independencia appeared to be ashore, as she remained in the same position. The more we advanced, the more clearly we comprehended that the latter was aground. I determined, however, to continue the chase of the Covadonga; this I did for three hours, when I became convinced that the ten miles which separated us could not be overcome before sunset, and I believed it better to abandon the chase and return to the aid of the Independencia.

I then found that the frigate was a total loss, and I ordered my boats to bring off her people, and that the ship should be set on fire.

The details relating to the loss of the frigate appear in the accompanying report of her commander. He, with his subordinates, take passage in the Chalaco to place themselves under your orders.

I returned to Iquique, and sent the prisoners on shore to the commanding general of the army there; the wounded were cared for, and the dead were buried.

From prudential motives, I stood out to sea, with the object of passing the night under steam, reconnoitring in the neighborhood of the port; and at daylight I sighted the Chalaco, which was at Pisagua. I communicated with her, and directed her to finish her commission at the port of Iquique, deeming it more convenient.

I am now coaling; taking coal from the Chalaco, from shore, and from a captured launch, with the purpose of following out your instructions.

In conclusion, I have the satisfaction of assuring your Excellency that every individual of the Huascar's crew, under my command, did his duty. All of which I have the honor to bring to your notice as the incidents which have occurred up to the present moment.

God keep your Excellency.

MIGUEL GRAU.

Report of Captain More, commanding the Peruvian ironclad Independencia.

Iquique, May 22nd, 1879.

To the Captain Commanding the First Naval Division.

Sir:

In accordance with the orders received from you, I left Arica on the 20th instant at 8 P. M.; when off Pisagua I awaited your vessel, which had entered that port.

At 4 A. M., of the 21st, I went ahead full speed in your company, keepin a short distance from the coast, until 5.30 A. M., when we came in sight of the port of Iquique; the Huascar was, at this time, about two miles ahead of me. At 7.30 A. M., we made out in the port, very close to the shore, three steamers, which we recognized as the Chilian sloop-of-war Esmeralda, the gunboat Covadonga, and a transport.

At this time, they were steering to the south; but, seeing that the Huascar would cut off their escape, they turned, the Esmeralda steering north. At this moment your ship opened fire on the Covadonga and I ordered my batteries to open on the Esmeralda. Taking advantage of these circumstances, the transport headed south, going at full speed. The fight was thus commenced. The Huascar, heading around, next directed her fire at the Esmeralda. The Covadonga attempted to escape, hugging the island. I steered in the same direction, in order to prevent her. I could not accomplish my object, because, when she arrived off the island, the Covadonga kept close to the dangerous places, and I could only follow her.

Seeing that the enemy was making the best use of the advantage his light draft gave him, I tried to get in-shore of him. and force him to go further out or to turn back. This I attempted in the first cove of the bay of Cheuraúate, turning my bow to the north and firing my starboard broadside; but the Covadonga continued to steer south, slipping from cove to cove. I could continue the combat only by following the enemy; who kept close to the coast, dodging from shoal to shoal, and running in water so shallow that the Independencia followed with great difficulty.

The fight had now lasted more than three hours. In view of this, and the uncertainty of the practice of my gunners—they being all raw hands—, and the effect produced by the well-sustained and well-directed small-arm and mitrailleuse fire of the enemy, which kept our crew below, I determined to use the ram. This I did twice, when circumstances permitted it; but, presently, finding shallow water, was obliged to haul off. The enemy was thus enabled to increase his distance.

When close to Punta Grueso, I determined to attack again with the ram, to pen her up in the bay; the soundings gave eight and nine fathoms, and the chart showed the bay clear of obstructions. At this moment, noticing that she hugged the shoals of the point more closely, I ordered the helm to be put to port, in order to pass her and attack advantageously on the other side. This I could not accomplish with the necessary celerity; because, at this moment, three helmsmen were wounded by the well-sustained mitrailleuse and small-arm fire which the enemy kept up from his tops. I gave the order to back full speed: the leadsmen continued to give the same soundings outboard—namely five fathoms of water. At this moment, when the ram touched the Covadonga, a severe shock was felt, and the frigate remained stationary. She had struck a rock which is not marked on the chart; for it is north of the last which appears on it.

By the first blow, the vessel became filled with water, the fires were put out, and the boilers were broken from the up-takes; and, by a second and third shock, the other sections were flooded. The ship fell over on her starboard side, and the water came in through the battery ports. Notwithstanding our condition, the Covadonga, passing to starboard fired her guns; our guns answered, with the water almost over them. We continued to

fire with the mitrailleuse and rifles, the crew being ordered on deck, until the ammunition was expended; we being unable to get any more, because the ship was full of water.

The Covadonga continued firing slowly; one of her shells carried away the spanker gaff, where the flag was hoisted. I immediately ordered it to be re-hoisted on another halliard.

After striking I had soundings taken all around the vessel. The soundings gave from five and a half to six fathoms; which proves that the rock we struck stands alone, and at a distance from the shoals off the point.

When I was satisfied that all attempts to save the vessel were useless, I ordered the magazine to be fired. The officer charged with this duty tried to fulfil it; but it was too late, for the water, which was coming in in torrents, prevented him.

Feeling that it would be impossible to prevent nearly all the crew, [consisting of men unaccustomed to man-of-war discipline, embarked only a few days before we left Callao], from jumping overboard, and running the risk of drowning, I ordered all the boats to be lowered to take the people ashore, collecting in the first all the wounded and placing each boat in charge of two officers, so that they might return for the rest of the people. Finally, I ordered my second in command, Commander Raigada, to organize the people on shore, and to send back the boats. This latter, however, was not done, as they were all destroyed in the surf in getting ashore.

Without doubt, had this not occurred, all the crew would have been saved, as there remained with me on board only twenty persons. Among these were 1st lieutenants don Pedro Gaseron and don Melchor Ulloa, 2nd lieutenant don Alfredo de la Haza, Ensign don Ricardo Herrera. Midshipman don Carlos Elespuru, the correspondent of the "Comercio," don Jose Rodolfo del Campo, Doctor don Enrique Basadre, and Chief Machinist don Tomas Wilkins and his assistant.

Later, the vessel under your command approached us, and sent three boats to transport those who remained in the frigate. This was not done until, finding that we could not set fire to the ship, we spiked the guns and threw the small-arms overboard.

I send you also a list of the killed and wounded on board the frigate under my command during the action.

It remains now only to bring to your notice the good conduct of the other chief officers, officers, and crew of the ship; all showed bravery and coolness throughout, and did not leave, for an instant, their stations.

I ordered the second in command to superintend all parts of the ship during the action; the third in command to take charge of the batteries; and, as he was placed *hors de combat* by one of the first discharges of the enemy, I replaced him by Commander don Josè Sanchey Lagomarsino, who was on board as chief of the detachment of volunteers; and who, up to this time, had been at my side, with 1st Lieutenant don Narciso Garcia Y Garcia, Signal-Officer Salaverry, and my aid, 2nd Lieutenant don Enrique Palacios.

I will not close without informing you that one of the last rifle shots of the enemy instantly killed don Guillermo Garcia Y Garcia, one of our most intelligent naval officers.

God keep you.

JUAN G. MORE.

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Report of Captain Condell, commanding the Chilian gunboat Covadonga.

On board the gunboat Covadonga,
Antofagasta, May 27, 1879.

I have the honor to report to you the fight which took place between this vessel and the Esmeralda [which had remained to sustain the blockade of

Iquique, after the departure of the admiral's ship and the rest of the squadron], with the Peruvian ironclads Huascar and Independencia.

At about half past six in the morning of the 21st instant, while we were guard-ship outside of the port, we saw, to the north, the smoke of two vessels, which, soon afterwards, we recognized as the two ironclads just mentioned. I immediately signalled this to the Esmeralda, who signalled us to "follow in her wake;" and we prepared for action, and went out to fight.

Eight o'clock was striking when a projectile, fired by the Huascar, struck between our two vessels, which were within hailing distance. The fight then began; we opened our fire; the Huascar steered for the Esmeralda, and the Independencia for the Covadonga. In view of the superiority of the enemy, which was increased by about thirty boats which stationed themselves along the beach, and seeing that, whatever efforts we might make within the port, it would be difficult, if not impossible, to conquer or escape from an enemy ten times more powerful than ourselves, I determined to steer to the south, keeping as close to the coast as possible.

Meanwhile, the Esmeralda remained fighting in the port. During four consecutive hours, we received the fire of the Independencia. Several shots struck us, one went through the skiff and its davits, the main shrouds, and the foremast. Three times she approached us right astern to sink us with her ram. In the first two, she did not dare attempt it, whether from fear of the shoalness of the water, or of the well-sustained cannon and musketry fire which we kept up; she, all the while, replying to this latter in kind, and with, besides, her mitrailleuses from the tops. The third attempt, it seemed to us, must be decisive; but, at two hundred and fifty metres distance from our stern, we gave her some 70-pdr. shot, which caused her to steer towards the shore, and ground on a shoal that we had bumped over.

We steered so as to place ourselves under the enemy's poop, where she could not fire at us. Passing by him, we fired two 70-pdr. shots, to which he replied with three shots without striking us.

As we saw the standard and Peruvian colors of the ironclad hauled down from her mastheads, and the parliamentary flag replace them, the crew cheered enthusiastically I came within hail of the surrendered ship, whose captain told me that he had hauled down his flag, and asked me to send a boat aboard him. This I could not do, notwithstanding my desire to do so, because the Huascar, which we had left at Iquique, was approaching. Meanwhile, the crew of the Independencia were abandoning their vessel, and going ashore, some by swimming, and others in boats.

As my engine was working with only five pounds pressure, and as the vessel was making water fast through the shot holes she had in her, I thought it inadvisable to take possession of the surrendered frigate; and I therefore retired to the south, having the full conviction that the Independencia would remain fast.

The Huascar, which, as I have said, I left fighting in Iquique roads, now approached us under all steam. I took precautions to prevent a second attack, which, from our shattered condition, it appeared impossible to avoid.

We got up some solid shot, and the crew were given rest, after their five or six hours fight with the two ironclads. Shortly after, and when the pursuer was about six miles from us, and on the quarter of the surrendered ship, I saw him steer towards the latter. This enabled us to get away from him a little more; but, not long after, I saw him again steering for us, at a distance of about ten miles.

When night came on, we lost sight of him, and, in order to take advantage of the breeze which was blowing, I steered to the west. I continued to steer in this direction until midnight, when believing that the Huascar must have ceased her pursuit, I steered for the coast. We went into Tocopilla, where we made, with the help of the carpenters from the shore, the repairs which we most needed. We started south again in the morning of the 24th, touching at Colija at half past one P. M. Here, we met the steam-

er from the North, which took the paymaster and the wounded to Antofagasta, with orders to send a steamer to our assistance; for we could not steam more than two knots, and the vessel was still making a great deal of water. Twenty miles from Antofagasta, the Rimac took us in tow, and brought us here, where we anchored at 3 A. M., of the 26th.

CARLOS A. CONDELL.

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The following is taken from the Chilian Times of June 7th.

The Last Moments of the Esmeralda.

The official report of the second commandant of the Esmeralda, don Luis Uribe, has been published. Most of the particulars related have already appeared, but the following corrects some of the details hitherto to hand, and will be read with interest. We may premise that, on taking up her position, two of the boilers of the Esmeralda gave out, which reduced her speed to two or three miles an hour. This is the best proof of the condition the heroic little vessel was in to meet her gigantic adversary.

Sènor Uribe says:—"The Huascar, seeing the ill-effects of her shots, proceeded to ram the Esmeralda. Our reduced speed prevented Captain Prat from evading the blow, and the ram struck us on the port side opposite the mizen mast; while the turret guns, discharged while the yards were touching, made terrible havoc among our crew. Captain Prat, who was on the bridge from the beginning of the engagement, sprang on the bows of the Huascar, shouting, at the same time, to board her. Unfortunately, the noise produced by the broadside directed at the Huascar, prevented his voice from being heard; and, of those who were on the bridge with him, only the sergeant had time to follow, such was the rapidity with which the Huascar withdrew her ram from our side. I was on the forecastle, and, from there, had the grief of seeing the brave Captain Prat fall, fatally wounded, at the very foot of the turret of the Huascar.

Upon this, I took command of the vessel. We continued to fight point-blank without our projectiles having the least effect on the enemy, whilst his committed dreadful havoc; our decks were strewn with corpses.

Again the Huascar returned to the charge, aiming directly at the middle of our vessel. I endeavored to avoid the shock, but the Esmeralda moved so slowly that it was impossible, and we received the second ram on the starboard bow. On this occasion, Lieutenant Serrano, who was on the forecastle, sprang on board the Huascar, followed by about twelve men. On the latter's deck, not an enemy was to be seen, but from the turret and poop defences poured a deadly fire of musketry and mitrailleuses.

The gallant Lieutenant Serrano, and nearly all those who went with him, were shot down ere they had advanced many paces. The speed with which the Huascar retired, and the slowness of the Esmeralda to lay alongside, which was the only way by which our men could get on the enemy's deck, rendered all attempts at boarding impossible. By this time, our crew had greatly diminished. Upwards of one hundred were *hors de combat*, the powder magazine inundated, and the engine disabled. The few cartridges that remained on deck served to give the last broadside, on our receiving the third ram of the enemy. Midshipman Ernesto Riquelme, who behaved himself bravely throughout the action, fired the last shot; he was not seen afterwards, and it supposed that he was killed by one of the last shells of the Huascar.

A few minutes after being rammed the third time, the Esmeralda went down with all her crew, and with her flag still flying from her mizen masthead; fulfilling thus the desires of our unfortunate commander, who, on beginning the battle, said: 'Boys, the contest is unequal. Our flag has never yet been lowered before an enemy, and I hope this will not be the occasion when it shall be done. Whilst I live, that flag shall keep its place; and if I die, my officers will fulfil their duty.'"

# THE RECORD

OF THE

# UNITED STATES NAVAL INSTITUTE.

NAVAL ACADEMY, ANNAPOLIS,

Nov. 13, 1879.

Lieut. W. H. Brownson, U. S. N., in the Chair.


## TORPEDOES—THEIR DISPOSITION AND RADIUS OF DESTRUCTIVE EFFECT.


By Lieut. Commander C. F. Goodrich, U. S. N.


The thorough investigation of this subject has as yet to be made. Although experiments bearing upon it have been instituted and carried out in various quarters and in large numbers, no one has collected them and determined their joint value, mainly for the reason, that in but few cases has the same plan been followed, or have similar measurements been adopted, so that what might have been useful data are not comparable.

For instance, some experimenters have used pressure gauges to register the force of submarine explosions in foot pouuds; others have measured or estimated the height of the column of water ejected; others, both its height and the diameter of its base; others, the size of the *crater* formed in the mud at the bottom; others, again, the effect on hulls and floating or submerged targets of various builds and materials. These measures are all more or less valuable, but the connecting links between them are still unknown. What relation exists between a blow of five thousand lbs. to the square inch at a horizontal distance of ten feet from a centre of explosion as many feet below the surface and a *crater* nine feet broad and four feet deep in the bottom twenty-five feet below? Or how know that a shock which makes a hole fourteen feet square in a wooden frigate will not sink the *Hercules?*

Such are some of the preliminary questions to be solved before it will be possible either to predict the exact effect, the circumstances being given, or to accurately adjust the means employed to the end sought.

Let us prepare for a consideration of certain experiments by attempt-

ing, as far as may be, to obtain a notion of the phenomena accompanying an explosion, bearing in mind the possible necessity of future revision.

In the first place, there is formed a spherical wave of compression, propagated equally in all directions, followed later by a wave of rarefaction ; the former, due to the sudden generation of gas, and the latter to the subsequent return rush of the displaced water. It is the shock of this wave which, doubtless, occasions the rupture of torpedo cases planted close at hand, which cuts their cables and breaks their joints and connections. The energy upon the unit of surface of this wave decreases as the square of the distance increases, so that its effect ceases to be dangerous at a comparatively short distance, about six times the radius of destructive effect, according to Stotherd.

In the second place, at the same instant the products of the explosion form a sphere of gas at a very high temperature and under enormous pressure. This seeks relief in all directions, finding it, principally, along the line of least resistance. Ordinarily this line is vertical and it passes through the centre of the disturbed area on the surface. An outward sign of the work performed by the explosion is the column of water driven to a height dependent mainly upon the size of the charge and the immersion. This height occasionally exceeds four hundred feet. If, at any point within the spherical surface containing the gas, a ship's side or bottom should be found offering less resistance than that of the water vertically over the centre of explosion the hull will inevitably yield under the blow. It is readily seen that the more remote the hull is from this vertical axis, the greater will be the vessel's chance of escape.

The distance measured on the surface from a point vertically over the centre of explosion to the side of the vessel, when the latter is just within the area of danger, is called the radius of destructive effect. This definition is independent of any opinion we may form as to the justice of a somewhat general belief, that the circumference of the violently disturbed surface area is the line of division between danger and safety.

In the third place, immediately following the first report or shock, a second and less powerful one is often noticed, due to impact with the bottom of that portion of the gas sphere which has expanded downwards. This effect is, of course, most striking in shallow water. The first upward rush of the clear water originally over the torpedo, now gives way to muddy water, stirred up at the bottom by the secondary

shock, and carried along by the inward and upward draught into the partially rarefied space formed by the condensation of certain gaseous products of explosion, as well as urged by the positive action of the under wave after rebounding from the bottom.

While the energy of the explosion is thus divided into two parts, it is only that part which is instrumental in causing the water column and the circular disturbance area that we need consider with reference to the effect produced on vessels.

It has been found that this effect is influenced by several conditions. They may be indicated in the following general terms.

1st. The nature and condition of the explosive employed.

2nd. The strength and shape of the containing case, if the explosive be non-detonating.

3rd. The nature and mode of ignition.

4th. The immersion of the torpedo.

5th. The depth of water.

6th. If a ground torpedo, the nature of the bottom.

To illustrate briefly under each head,

1st. Gunpowder has but a fraction of the power of certain other explosives, and the latter are seriously affected by their physical or mechanical condition as, for instance, loosely or tightly packed. Again, quick burning gunpowder gives better results than slow.

2nd. Unless the explosive be susceptible of detonation when but slightly confined, a certain amount of tensile strength is necessary to the complete combustion of the charge and the consequent thorough development of its store of energy. Thus the English vary the thickness of their wrought iron cylindrical cases with the charge as follows:—

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Mine | of | 100 | lbs. | .109 | inch | thickness | of | case. |
| " | " | 250 | " | .188 | " | " | " | " |
| " | " | 500 | " | .25 | " | " | " | " |
| " | " | 1000 | " | .5 | " | " | " | " |

These thicknesses they believe to be rather under than over the proper value.

The Dutch torpedo cases are even heavier than the English though of the same material and somewhat similar shape. Very careful experiments have led to the adoption for the

Mine of 100 kilos. (221 lbs) of a thickness of 5 m m (.2 in.)
" " 190 " (419 " ) " " " " 8 " " (.35 in.)

*Cæteris paribus,* the spherical shape has been shown to permit the greatest *development* of the energy of explosion of gunpowder.

3rd. The explosion of a charge may be effected either by simple ignition or by detonation. If the former be employed, it has been found that large charges require several centres of ignition, so arranged that rupture of the case shall ensue, as nearly as may be, at the moment when the combustion is complete.

Major King thinks that the complete combustion of powder extends not farther than thirteen inches from the centre of ignition in tin cases. I am confident that he has, if anything, rather understated the truth. It is well to bear in mind, that intervals of time so slight as to escape observation and measurement may be, and doubtless are, in torpedo explosions, factors of vast importance in the result achieved.

4th. Assuming for the purpose of illustration that the water column is an index of the available energy of explosion while not strictly a measure, it is evident that, at the surface, a torpedo will cause no column whatever. Immediately beneath the surface, in place of the column there will be a mere cloud of spray. If the immersion be gradually increased, the height of the water column will also increase up to a certain point, the maximum for that charge. An increase of immersion is now followed by a rapid decrease of the height of the water column. It is not positively demonstrated, although there is good ground for supposing, that the best immersion of a torpedo of given charge is that corresponding to the maximum height of water column, since, apparently under those conditions only, is the greatest fraction of the energy of the explosion expended in causing actual displacement of the overlying water. It is, in any event, true that if the immersion be too great, the explosion is muffled and its energy is taken up by the large body of water over it. And here let me remark that, practically, the body of water over a torpedo is a cone whose apex is the centre of explosion and whose base is the disturbed circular area at the surface.

5th. The depth of water has its bearing upon the general result when so slight as to permit the wave of rebound already mentioned to reinforce the upward wave. When the distance from the torpedo to the bottom is zero, or, in other words, if the torpedo be a ground torpedo, the two waves combine more or less, causing an effect usually estimated at nearly twice that of a buoyant torpedo containing the same charge.

6th. This rebound of the under wave being of the nature of a re-

flection, it follows that the reflection will be greatest on very hard, elastic bottom. If the bottom be soft and inelastic, a considerable fraction of the energy is wasted in digging out great holes in the mud, to which the name of *craters* has been given.

It is proper to call attention here to the report of a series of experiments made at Willet's Point in 1865, by Major King of the Engineers, which is quoted by Barnes. This was the first attempt at reaching quantitative results. King used pressure gauges to register the force of submarine explosions, varying the conditions of depth and size of charge, distance of target and mode of ignition. He demonstrated beyond cavil the inability of an air chamber to give direction to an explosion (a theory then advanced by Wood and Lay and Ericsson) and the value of multiple ignition of gun powder. An extension of this method would have doubtless revealed the exact nature of the relation between charge and effect. That Major King was not enabled to execute his well-considered plans is very much to be regretted.

As a rule, nearly every other set of experiments has had for its object the elucidation of some one of the above mentioned points. Comparatively few have been made for determining the value of a charge under various conditions against the hull of a ship. The great cost has prevented any but the most wealthy nations from applying this crucial test. The few instances of this kind are of course most instructive. By their help we can use practice as a check against speculation.

There are three objective points in the study of the question of submarine explosions.

1st. The depth at which any given charge is most effective that we may plant our torpedoes so as to waste least energy.

2nd. The radius of destructive effect of any given charge.

3rd. How closely together the members of a group can be planted without endangering the cases, cables and connections of one torpedo by the explosion of its neighbor.

## 1st. DEPTH AT WHICH EFFECTIVE.

The Confederates made a number of experiments to determine the relation which should exist between the size of the charge and its immersion. From these experiments has been derived the rule, that in the case of a ground torpedo on hard bottom, the weight of the charge in pounds should equal the square of the depth in feet. For buoyant torpedoes, or ground torpedoes on soft bottom, this weight should be in-

creased by one fourth. This rule is designed for depths between 20 and 40 feet. For less depth we may assume

$$D=\sqrt{C}$$

where C is the charge in pounds and D the immersion in feet. From the tenor of Stotherd's remarks under this head, it would appear as though this simple empirical rule still found favor with the English.

The French have, as might be imagined, given the whole subject of submarine explosions much study. Their experiments furnish the basis of several suggestive solutions.

M. Lefort, Capitaine de Vaisseau, found that two hundred kilos. (441 lbs.) of powder were most effective at an immersion of six metres (19.8 feet). From this and other observations coupled with the assumption that the force of explosion was proportional to the cube root of the charge, he drew the expression

$C=.927\ D^3$, where C is in kilos of powder; D in metres,
or $C=.58\ D^3$ " " pounds and D in feet.

Lieutenant Audic, of the French Navy, who has furnished a most thoughtful essay on this subject, of which I have not hesitated to avail myself largely, suggests a still simpler form.

$C=D^3$ C in kilos of powder; D in metres.
$C=.062\ D^3$ " pounds and D in feet.

This formula had however been previously announced in 1868 by Captain-Lieutenant Vandevelde of the Dutch Navy, the head of the Dutch Torpedo Corps. In his report for 1871, he mentions having verified this law for immersion under four metres (14 feet).

The German rule reduced to English weights and measures is simply

$$C=\frac{D^3}{16} \text{ or } .063\ D^3$$

As a result of their experiments, principally at Carlskrona during the years 1874, 1875 and 1876, the Scandinavian powers were led to adopt

$C=.956\ D^3$ in kilos and metres
or $C=.06\ D^3$ " lbs. " feet.

Admiral Bourgois, of the French Navy, in an interesting report quoted by Audic gives incidentally what he deemed the best immersion for certain heavy charges of gunpowder. These, as well as the regulation depths for French defensive torpedoes, are specifically mentioned in the following table, calculated up to a depth of 40 feet.

## BEST IMMERSION FOR BUOYANT TORPEDOES CHARGED WITH POWDER.

CHARGE IN POUNDS ACCORDING TO

| Depth in Feet. | Stotherd. $C=D^2$ | Lefort. $C=.058D^3$ | Audic. $C=.063D^3$ | French Regulatn. | Scandinavian. $C=.06D^3$ | Germans. $C=.063D^3$ |
|---|---|---|---|---|---|---|
| | 25 | 725 | 7.5 | | 7.5 | 7.8 |
| 10 | 100 | 58 | 62 | | 60 | 62.5 |
| 15 | 225 | 196 | 209 | | 203 | 211 |
| | $C=\frac{5}{4}D$ | | | | | |
| 20 | 500 | 464 | 494 | | 479 | 500 |
| 25 | 780 | 906 | 969 | | 938 | 977 |
| 30 | 1125 | 1566 | 1674 | 2206 | 1620 | 1688 |
| 35 | 1530 | 2487 | 2658 | | 2573 | 2805 |
| 40 | 2000 | 3712 | 3968 | | 3840 | 4000 |
| 50 | | | | 3309 | | |

Having found the charge of powder necessary for a given depth, according to any one of these formulæ, its equivalent in another explosive is simply and readily obtained if we know the value of the later as compared with the former.

The most cursory glance shows how discordant are the views of different speculators on this point. The nearest approach to agreement is found at immersions between fifteen and twenty feet. These it may be remarked, are the depths at which contact torpedoes will be encountered. It is safe to assume that we may expect to find charges of about two hundred to two hundred and fifty pounds of powder or its equivalent used at the depth of fifteen feet, five hundred pounds at twenty feet, and vastly increased quantities at still greater depths.

The necessity for such enormous charges in ground mines guarding deep channels will, in practice, undoubtedly compel the defence to resort in the main to buoyant torpedoes.

### 2nd. THE RADIUS OF DESTRUCTIVE EFFECT.

The relation existing between the size of the charge in pounds and the radius of destructive effect in feet has been pointed out more or less exactly in a number of empirical formulæ. Stotherd writes $R=2\sqrt[3]{C}$, where R is the radius of destructive effect in feet, and C the charge in pounds of gunpowder fired on the bottom.

This formula is only advanced as an approximation. It was derived from the results of a large number of explosions made at Chatham for the Floating Obstructions Committee. He further states that it is

true only when the charge is at its best immersion and that the value of the expression is confirmed by a long series of experiments made by the Austrians.

The expression for the radius of destructive effect in the case of buoyant torpedoes can be inferred from the statement that buoyant charges should be about one fourth heavier than ground charges. That is to say five pounds in a buoyant torpedo would be equivalent to four pounds in a ground torpedo. The radius of destructive effect of the former would be nine tenths that of the latter.

For gun-cotton, Stotherd writes $R=2\sqrt[3]{4C}$.

M. Lefort, Capitaine de Vaisseaus of the French Navy, suggests

$R=1.26\sqrt[3]{C}$ in metres and kilos,

or $R=3.18\sqrt[3]{C}$ " feet " pounds.

This expression is based upon measurements of craters formed in the sand bottom under the place of explosion. I am unable to discover the variation in the radius of destructive effect which Lefort found to exist in the two cases of ground and buoyant torpedoes.

The Scandinavian Torpedo Commission of 1874—1876 also assumed that R was proportional to $\sqrt[3]{C}$, and sought a numerical value for the co-efficient connecting the two. From experiments upon a floating lattice target, and measurements of the holes made in ice which had been allowed to form over the torpedo they concluded

$R=1.44\sqrt[3]{C}$ in kilos and metres,

or $R=3.63\sqrt[3]{C}$ " feet " pounds.

This is merely the extreme value of the radius of destructive effect for buoyant torpedoes. To obtain its value, when a breach is effected, a subtractive correction must be applied varying with wooden ships from five to eight feet, according as the torpedo is nearest the bottom or the side, and with an iron vessel of the *Hercules* type from 8.5 to 11.5 feet under similar conditions.

If Dynamite be used, $R=5.47\sqrt[3]{C}$

" Gun-cotton " " $R=5.34\sqrt[3]{C}$

For ground torpedoes $R^1=\frac{5}{4}R$.

M. Moisson, Capt. d'Art., published in 1871, a very elaborate article on this subject. His mode of reasoning may be thus briefly resumed. Supposing the water destined to form the ejected column to be divided into differential pyramids, all having their summits at the centre of the torpedo, the centre of gravity of any pyramid inclined to the vertical at any angle $\zeta$ will be raised to a height given by the formula

$$h = \frac{1}{2} gt^2 \left[\frac{3R^2 p}{D^3} \cos{}^4\zeta - 1\right]^2$$

where D, is the immersion in metres,
g, the acceleration of gravity,
p, the pressure in metric tons upon a sphere of R, radius,
t, the time in seconds.

The measurement of the base of the column gives the angle $\zeta$ corresponding to $h=0$. The constants of his equation were found from experiment. Its final shape is

$$\sqrt{C} = \frac{D^2+R^2}{R^2} \times \frac{D^2+R^2+\sqrt{[(D^2+R^2)^2+4{,}250{,}000]}}{3{,}900}$$

where C is the charge in metric tons,
R the corresponding radius of destructive effect in metres.

Audic offers a graphic solution of the whole problem of the relation existing between C, D, and R. In this solution R varies as $\sqrt[3]{C}$, but the co-efficient linking R and D is a variable which passes through a maximum value, when

$D = \sqrt[3]{C}$ in kilos. and metres,
or $D = 16.13 \sqrt[3]{C}$ in pounds and feet.

The solution is based upon the following assumptions.

1st. That R is a function of $\sqrt[3]{C}$.

2nd. That the co-efficient of $\sqrt[3]{C}$ varies with the immersion.

3d. That for the same immersion, increased charges augment the radius of destructive effect but slightly beyond a certain amount.

Audic presents two curves as furnishing the solution to any given numerical form of the question. The first is constructed with different values of $\frac{D}{\sqrt[3]{C}}$ (in kilos and metres) as ordinates. The abscissæ are values of the coefficient K which connects R and $\sqrt[3]{C}$ in the equation $R = K \sqrt[3]{C}$. This radius is the distance at which the charge is *barely* effective.

In order that the explosion may occasion a breach in a ship of the well known *Hercules* type, the action must extend over a certain surface, in other words, the radius of destructive effect as thus found, be somewhat diminished. Audic's second curve gives this subtractive correction for any given charge. The accompanying tables are made from measurements of Audic's curves turned into pounds and feet. The resulting radius of destructive effect is the horizontal distance to the vertical axis of the torpedo from the *nearest* point of the hull.

Lastly, Audic proposes reducing the radius of destructive effect in each case by about $\frac{1}{12}$ the beam of the ship to obtain the radius of destructive effect according to our definition.

TABLE I (CURVE A).*

| $\frac{D}{\sqrt[3]{C}}$ | K | $\frac{D}{\sqrt[3]{C}}$ | K | $\frac{D}{\sqrt[3]{C}}$ | K | $\frac{D}{\sqrt[3]{C}}$ | K | $\frac{D}{\sqrt[3]{C}}$ | K | $\frac{D}{\sqrt[3]{C}}$ | K |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1.51 | 2.1 | 2.60 | 3.2 | 2.42 | 4.3 | 1.63 | 5.8 | 1.11 | 8 | .67 |
| 1.1 | 1.66 | 2.2 | 2.64 | 3.3 | 2.35 | 4.4 | 1.59 | 6.0 | 1.06 | 8.2 | .65 |
| 1.2 | 1.82 | 2.3 | 2.66 | 3.4 | 2.26 | 4.5 | 1.54 | 6.2 | 1.02 | 8.4 | .62 |
| 1.3 | 1.94 | 2.4 | 2.68 | 3.5 | 2.17 | 4.6 | 1.49 | 6.4 | .97 | 8.6 | .58 |
| 1.4 | 2.07 | 2.5 | 2.70 | 3.6 | 2.09 | 4.7 | 1.45 | 6.6 | .92 | 8.8 | .55 |
| 1.5 | 2.21 | 2.6 | 2.68 | 3.7 | 2.03 | 4.8 | 1.41 | 6.8 | .88 | 9 | .54 |
| 1.6 | 2.29 | 2.7 | 2.66 | 3.8 | 1.97 | 4.9 | 1.37 | 7 | .84 | 9.2 | .53 |
| 1.7 | 2.37 | 2.8 | 2.65 | 3.9 | 1.89 | 5 | 1.33 | 7.2 | .80 | 9.4 | .53 |
| 1.8 | 2.44 | 2.9 | 2.58 | 4 | 1.82 | 5.2 | 1.28 | 7.4 | .76 | 9.6 | .52 |
| 1.9 | 2.51 | 3 | 2.53 | 4.1 | 1.76 | 5.4 | 1.22 | 7.6 | .73 | 9.8 | .52 |
| 2 | 2.57 | 3.1 | 2.47 | 4.2 | 1.69 | 5.6 | 1.15 | 7.8 | .71 | 10 | .51 |

TABLE II (CURVE B).

| $\sqrt[3]{C}$ | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| —b | | 9.7 | 7.5 | 6.3 | 5.2 | 4.1 | 3.2 | 2.4 | 2.2 | 1.4 | 1. | .7 | .4 |

The only practical means of deciding upon the respective merits of these conflicting formulæ, is to subject them all to the crucial test of actual experience. In the following table are brought together the principal experiments upon the hulls of vessels as far as known and the actual results compared with those calculated by the various methods described.

It is evident that the methods of Lefort and the Scandinavians are too frequently in error to warrant much confidence, while the English formula for all and Audic's curves for large charges, give results

* As will be observed, the variation of K gradually decreases; indeed, Audic makes his axis of $y$ an asymptote to the curve. In this I am sure he is wrong. The curve and the axis of $y$ should meet at some finite distance from the origin; since there is, undoubtedly, a particular depth at which any given charge ceases to be operative. I should be disposed in practice to distrust the values of K beyond that for $\frac{D}{\sqrt[3]{C}}=9$ or 10. I regret my inability to prove by numerical examples my lack of confidence beyond this point, but in the experiments which might be available, other factors have been allowed to enter in such a manner as to escape elimination. The careful nature of Audic's investigation warrants this explanation.

TAB

GROUND

| Number of Experiment. | Kind of Explosive. | No. of lbs. | Immersion. | Dist. fr. Target. Direct. | Dist. fr. Target. Horiz'tal. | Name and Type of Ship, etc. | Series of Experiments. | Effect esti Stotherd. R. D. E. | Stotherd. Fatal. | Lefort R. D. E. |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Gunpowder. | 50 | 42 | 30 | | Monitor *Montauk.* | | 7.4 | yes. | 11.8 |
| 2 | " | 150 | 22 | 19 | 2 | Wooden Ship, *Terpsichore.* | | 10.6 | " | 16.9 |
| 3 | " | 662 | 40.2 | | 0 | " " *Audacious.* | | 17.4 | " | 27.7 |
| 4 | " | 1103 | 36.2 | | 24.6 | " " *Marie.* | | 20.7 | no. | 32.9 |
| 5 | " | 1103 | 33 | | 16.4 | " " *Cormoran.* | | 20.7 | yes. | 32.9 |
| 6 | " | 2000 | 36 | 28 | | " " *Com. Jones.* | | 25.2 | " | 40.1 |
| 7 | " | 2206 | 59 | | 22 | Iron Clad, *Requin.* | | 26 | " | 41.3 |
| 8 | " | 3309 | 52 | | 20 | " " " | | 29.8 | " | 47.4 |
| 9 | Gun Cotton. | 276 | 26.2 | | 24.6 | Wooden Ship, *Marie.* | | 20.6 | no | 32.8 |
| 10 | " | 500 | 48 | | 100 | *Hercules* bottom on *Oberon.* | a | 25.2 | " | 40.1 |
| 11 | " | 500 | 48 | | 80 | " " " | a | 25 2 | " | 40.1 |
| 12 | " | 500 | 48 | | 60 | " " " | a | 25.2 | " | 40.1 |
| 13 | " | 500 | 48 | | 48 | " " " | a | 25.2 | " | 40.1 |
| 14 | " | 500 | 48 | | 30 | " " " | a | 25.2 | " | 40.1 |
| 15 | " | 500 | 48 | | 0 | " " " | a | 25.2 | yes. | 40.1 |
| 16 | " | 739 | 27.2 | | 24.6 | Wooden Ship, *Express.* | | 28.8 | " | 45.8 |
| 17 | " | 918 | 39.4 | | 39.4 | " " *Marie.* | | 30.8 | no. | 49 |
| 18 | " | 1554 | 75 | | 19.7 | " " " | | 36.8 | yes. | 58 |
| 19 | " | 1624 | 66 | | 24.6 | " " *Eldorado.* | | 37.2 | " | 59.1 |

BUOYAN

| Number of Experiment. | Kind of Explosive. | No. of lbs. | Immersion. | Direct. | Horiz'tal. | Name and Type of Ship, etc. | Series of Experiments. | Stotherd. R. D. E. | Stotherd. Fatal. | Lefort R. D. E. |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Gunpowder. | 25 | 6 | 0 | 0 | Touching keel, wooden ship. | | 5.2 | yes. | 9.2 |
| 2 | " | 45 | 12 | 0 | 0 | Touching side of same. | | 6.8 | " | 11.4 |
| 3 | " | 53 | 6 | | | "Practically in contact" with side of *Minnesota.* | | 6.8 | " | 12.1 |
| 8 | Dynamite. | 16 | 5.75 | 2 | | Wooden ship. | b | 8.3 | " | 14.6 |
| 4 | " | 10 | 6.5 | 2.2 | | " " | b | 7 | " | 12.4 |
| 5 | " | 13 | 7 | 2.2 | | " " | b | 7 | " | 13.7 |
| 6 | " | 13 | 7.3 | 2.2 | | Double iron bottom on same. | b | 7.3 | " | 13.7 |
| 7 | " | 16 | 7.75 | 3 | | Wooden ship. | b | 8.3 | " | 14.6 |
| 9 | " | 18.8 | 9.3 | 10.5 | 7.7 | *Hercules* bottom on same. | b | 8.6 | " | 15.2 |
| 10 | " | 18.8 | 9.3 | 3.4 | —1.5 | *Hercules* bottom on same. | b | 8.7 | " | 15.2 |
| 11 | Gunpowder. | 100 | 16 | | 16 | Wooden ship. | | 8.3 | no. | 14.6 |
| 12 | " | 112.8 | 9.3 | 11.9 | —9.2 | *Hercules* bottom wooden ship. | c | 8.6 | " | 15.2 |
| 13 | " | 112.8 | 10.5 | 4.1 | 2 | " " " | c | 8.6 | " | 15.2 |
| 14 | Dynamite. | 32.9 | 9.3 | 25.6 | 23.4 | *Hercules* bottom wooden ship. | c | 10.4 | " | 18.4 |
| 15 | " | 32.9 | 9.3 | 16.8 | 14 | " " " | c | 10.4 | " | 18.4 |
| 16 | " | 32.9 | 9.3 | 12.8 | 10.2 | " " " | c | 10.4 | yes | 18.4 |
| 17 | " | 32.9 | 9.3 | 4.1 | 0 | " " " | c | 10.4 | " | 18.4 |
| 18 | " | 46.8 | 9.3 | 25.6 | 28.4 | " " " | c | 11.7 | no. | 20.7 |
| 19 | " | 65.8 | 9.3 | 21.1 | 18.7 | " " " | c | 13.1 | " | 23.2 |
| 20 | Gunpowder. | 200 | 22 | | 22 | Wooden ship. | | 10.4 | " | 18.4 |
| 21 | " | 287 | 15.4 | | 11.4 | Wooden gun boat. | | 11.9 | yes. | 21 |
| 22 | " | 450 | 19.4 | | 14.4 | " " | | 13.9 | no. | 24.3 |
| 23 | " | 441 | 23 | | 23 | *Marie & Express.* | | 13.7 | " | 24.2 |
| 24 | " | 441 | 19.7 | | 19.7 | Wooden ship, *Wagram.* | | 13.7 | " | 24.2 |
| 25 | " | 500 | 32 | | 32 | Wooden ship. | | 14.2 | " | 25.1 |
| 26 | " | 656 | 29.3 | 32.6 | 19.7 | *Hercules* bottom on wooden ship. | | 15.7 | " | 27.7 |
| 27 | " | 656 | 29.3 | 23.6 | 5.2 | " " " | | 15.7 | yes. | 27.7 |
| 28 | " | 662 | 29 | | 4.6 | Ship *Audacious.* | d | 15.7 | " | 27.7 |
| 29 | " | 2206 | 34 | | 34 | Wooden ship, *Wagram.* | | 23.6 | no. | 41.6 |
| 30 | " | 1324 | 28 | | 28 | " " | | 19.8 | " | 34.9 |
| 31 | " | 4410 | 131 | | —17 | Wooden ship, *Fulton.* | | 29.5 | yes. | 52.1 |
| 32 | Gun Cotton. | 500 | 48 | | 30 | *Hercules* bottom on *Oberon.* | a | 23.7 | no. | 40 |

a. The well known *Oberon* experiments reported in detail in *Engineering* March 10th, 1876.
b. The first Carlskrona experiments. A wooden ship was fitted with a section representing the l
proper. Vide Stotherd, page 38.
c. The second Carlskrona experiments detailed in the Report of the Scandinavian Torpedo Co
within reach.
d. The result is so totally different from the predictions, and indeed, so intrinsically improbable

III.

IARGES.

| l according to | | | | | | |
|---|---|---|---|---|---|---|
| Scandinav'n | | Audic. | | Result of Explosion. | Disagree with Results. | Authority. |
| R. D. E. | Fatal. | R. D. E. | Fatal. | | | |
| 11.8 | yes. | —— | no. | Extensive damages. | St. L. Sc. | Barnes. |
| 19.5 | " | —— | " | Sank the ship. | A. | Stotherd. |
| 34.5 | " | 7 | yes. | Keel broken, hole 10 sq. ft. | | Audic. |
| 52.5 | " | 31.6 | " | Insignificant. | L. Sc. A. | " |
| 54.5 | " | 27.2 | " | Hole 17′ by 12′ | | " |
| 52.2 | " | 28.8 | " | Total destruction. | | Barnes. |
| 54 | " | 15.8 | no. | Hull intact, armor knocked off. | St. L. Sc. | Audic. |
| 62.5 | " | 29.7 | yes. | Broke the ship in two. | | " |
| 38.4 | " | 21.9 | no. | Leak, no break. | | *Engineering.* |
| 41.3 | no. | 17.9 | " | A few tubes started. | | " |
| 41.3 | " | 17.9 | " | No damage. | | " |
| 41.3 | " | 17.9 | " | Slight effect. | | " |
| 42.8 | " | 17.9 | " | Effect inconsiderable. | | " |
| 43.8 | yes. | 17.9 | " | Serious leak and injuries. | L. Sc. | " |
| 44.3 | " | 17.9 | yes. | Wrecked the ship. | | " |
| 49.1 | " | 32 | " | Destroyed. | | Audic. |
| 54.8 | " | 37.9 | no. | Sank slowly. | St. A. | " |
| 71.5 | " | 28.9 | yes | Stove in. | | Torpedoes and See-Minen. |
| 72.8 | " | 36.5 | " | Broke in two amidships. | | Audic. |

HARGES.

| | | | | | | |
|---|---|---|---|---|---|---|
| 4 | yes. | — | no. | Hole impossible to stop. | A. | Daudenart. |
| 4.5 | " | | " | Large leak. | A. | " |
| 5 | " | | " | Frames broken and sprung, planks started. | St. L. Sc. | Barnes. |
| 6 | " | | " | Hole 10′ 5″ by 9′. | A. | Stotherd. |
| 4.6 | " | | " | " 4′ by 16′. | A. | " |
| 5.5 | " | 1.1 | " | " 15′ by 8′. | A. | " |
| 2.5 | " | 1.3 | " " | Oval hole, 4′ by 3′ in outer plating, large pieces blown out of inner. | A. | " |
| 8 | " | 5 | | Hole 8′ by 8′. | A. | " |
| 3.8 | no | 3.8 | " | Rivets broken, plates bulged in; no serious damage. | St. L. | |
| 3.8 | yes. | 3.8 | yes. | Large hole in outer plating, inner much bulged in but not broken. | St. L. Sc. A. | Rep't Scand. Torped. Com. |
| 8.6 | no. | 3.2 | no. | No effect. | | Daudenart. |
| 5.9 | " | 5.4 | " | Slight leak, rivets started. | L. | Scandinavian. |
| 9.4 | yes. | 6.1 | yes. | Hole in outer plating 76 sq. feet, inner 60 sq. feet. | | " |
| 6 | no. | 6.2 | no. | Little or no effect. | | " |
| 6 | " | 6.2 | " | " " " | L. | " |
| 6 | " | 6.2 | " | A few rivets started; outer plating buckled. | St. L. | " |
| 9 | yes. | 6.2 | yes. | Hole in outer, 54 sq. ft., in inner, 40 sq. ft. | | " |
| 8.2 | no. | 7.6 | no. | Little or no effect. | | " |
| 13 | " | 9.3 | " | Slight effect. | L. | " |
| 13.1 | " | 6 | " | Little or no effect. | | Daudenart. |
| 17.9 | yes. | 13 | yes. | Destroyed. | | Audic. |
| 21.9 | " | 17.4 | no. | Slight hole. | L. Sc. | " |
| 17.5 | no. | 16.7 | " | *Express* slight hole. *Marie* intact. | L. | " |
| 19.5 | " | 16.9 | " | Dangerous leak. | L. | " |
| 17.6 | " | 10.7 | " | Little or no effect. | | Daudenart. |
| 22.6 | yes. | 17.3 | " | Bad leak, kept under by pumps. | L. Sc. | Scand. Tor. Com. |
| 23.1 | " | 17.1 | yes. | Enormous leak in both hulls. | | " |
| 23.1 | " | 19.9 | " | 11 frames broken, side destroyed; no breach. | | Audic. |
| 39.6 | " | 34.4 | " | Leak, no break. | L. Sc. A. | " |
| 32 | " | 30.3 | " | " " | L. Sc. A. | " |
| 54.5 | " | 10.8 | " | Stove in bottom a hole 19 feet long. | | " |
| 31.5 | " | 23 | no. | Effect inconsiderable. | L. Sc. | *Engineering.* |

ı of the *Hercules* and the explosions were effected part against this target and part against the hull

sion. This valuable document could only be partially used, there being no English translation

have not used it as against the methods employed.

which are usually not far wrong. For small charges, Audic's curves are untrustworthy. They go to show for instance that thirteen pounds of dynamite exploded at seven feet nine inches immersion, in contact with a hull of the *Hercules* type are without serious effect, a conclusion thoroughly disproved by the first Carlskrona experiments. His first curve is based on clearly logical grounds, his second would appear to need revision. Generally speaking it is safe to accept the English rule, although it is obvious that this might be improved by the introduction of a coefficient similar to Audic's which should make the radius of destructive effect, as it really is, a function of the immersion as well as of the charge.

Some interesting experiments conducted at this Station during the summer of 1874, may be referred to as useful in emphasizing this connection. They are reported in detail in the Station pamphlet on Explosions. In brief, they consisted in detonating fifty pounds of nitroglycerine at various depths, all other circumstances remaining constant. It was assumed that the violently disturbed surface area was a measure of, if not absolutely coincident with, the district of danger. The radius of this area was found to be thirty-five feet for an immersion of thirty feet, twenty five feet for an immersion of sixty feet and much less for an immersion of ninety feet. In the last case but very slight effect was observed at the surface. Eighteen seconds after the jar of the explosion was felt, the water above began to boil. The diameter of the foaming area was about twenty-five feet at first. A curious fact connected with these experiments is that in the first two cases, where the overlying water experienced actual displacement, its volume was practically the same. It seems possible that between the limits of the best immersion for any charge ($D=\sqrt{C}$) and the least depth at which the charge is smothered, the radius of destructive effect will be found to vary nearly inversely as the square root of the depth and at these limits to tend rapidly towards zero.

### 3rd. OF THE INTERVALS BETWEEN TORPEDOES.

The wave of compression which is propagated in all directions through the water is instrumental in causing the explosion, by concussion, of neighboring torpedoes and the rupture of their cases, in shearing their cables and in disarranging their electrical apparatus and other attachments. These phenomena are noticed far beyond the radius of destructive effect. For this reason torpedoes can not be so planted that their circles of efficiency may overlap, but must be sep-

arated to a greater or less extent, according to the size and nature of the charge.

It will be seen, upon reflection, that the more violent explosives will generate a compressed wave which may be described as more *intense* than that occasioned by their equivalent in gunpowder, since detonation is practically instantaneous, while inflammation requires an appreciable length of time, and the *amplitude* of the wave, or its *intensity* will be the greater, the more sudden the generating shock.

We are thus led to expect particularly marked results from gun-cotton and dynamite torpedoes, while they are, on the other hand, more susceptible to concussion than gunpowder.

Experience in England has shown that five hundred pounds of gun-cotton in a ground torpedo (whose radius of destructive effect is about twenty-five feet) will seriously injure torpedo cases distant one hundred and seventy feet, and four hundred and thirty-two pounds of gun-cotton when immersed at different depths, but on the bottom, destroyed neighboring ground torpedoes within one hundred and forty feet. When this charge was buoyed twenty-seven feet from the bottom (the radius of destructive effect being less than twenty-four feet) the adjacent torpedoes were uninjured when at a greater distance than one hundred and twenty feet.

According to French experience, torpedoes containing from twenty-five to thirty kilos (fifty-five to sixty-five pounds) of gun-cotton (having a radius of destructive effect of about fourteen feet) injured their neighbors at thirty metres (about one hundred feet) distance.

In some Swedish experiments, charges of dynamite were exploded by concussion from the detonation of similar charges one hundred feet distant.

On the other hand, the Dutch appear to believe that they can plant their contact torpedoes (whose radius of destructive effect is less than thirteen feet), so near together as fifty feet with impunity. It is thought however that neighboring cables or attachments would probably suffer from the explosion so close at hand of two hundred and seventy-five pounds of gunpowder.

No exact formula can be drawn from these meagre data. Stotherd suggests spacing torpedoes at six times the radius of their destructive effect, but the Toulon experiments go to show that even this interval is not invariably safe when gun-cotton and *a fortiori*, dynamite is used.

It would doubtless be better to adopt, provisionally, the rule that gunpowder torpedoes may be planted at intervals of six times the ra-

dius of their destructive effect, but that when the higher explosives are employed the torpedoes should be separated by distances equal to eight times the radius of their destructive effect.

## CONCLUSIONS.

1st. The size of the charge for ground torpedoes in pounds of gunpowder or its equivalent should be equal to the square of the proposed immersion in feet; for buoyant torpedoes, at least one fourth heavier.

2nd. The radius of destructive effect of a ground torpedo in feet at this immersion is equal to twice the cube root of the charge in pounds of gunpowder or its equivalent; and of a buoyant torpedo nine-tenths that of a ground torpedo. For less immersions the radius of destructive effect diminishes rapidly towards zero at the surface*, while for greater immersions it decreases slowly becoming zero when the explosion is completely smothered by the overlying water.

3rd. Gunpowder torpedoes should be spaced at six times and guncotton and dynamite torpedoes at eight times the radius of their destructive effect.

### AUTHORITIES.

| | |
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| *Etude sur les effets des Explosions Sous-marines* | Lieut. Audic of the French Navy. |
| *Notes on Explosives.* | W. N. Hill, Torpedo Station. |
| *Die Torpedos und See-minen.* | Berlin, 1878. |
| *Report of Experiments &c.,* | Maj. W. R. King, U. S. A. |
| *Engineering and Engineer.* | Loc. cit. |
| *Report of Scandinavian Torpedo Commission.* | 1874, 75, 76. |

## NOTE.

The foregoing remarks are offered rather as a study than as an attempt at a complete treatise on the subject. For the benefit of those wishing to investigate the matter in greater detail, a list of authorities is herewith given.

C. F. G.

The Chairman.—The paper which has just been read is highly instructive and valuable, showing that the author has made extended researches into the subject. Dealing, as it does, with facts and figures it leaves but little opportunity for discussion, and I am sure all will unite with me in returning thanks to the author for his labors in this important branch of our profession.

* It will of course be understood that zero is merely a *limit* towards which it *tends*, not that, at the surface, *no* change is sufficient to breach the *Hercules*.

# THE RECORD

OF THE

# UNITED STATES NAVAL INSTITUTE.

NAVAL ACADEMY, ANNAPOLIS,

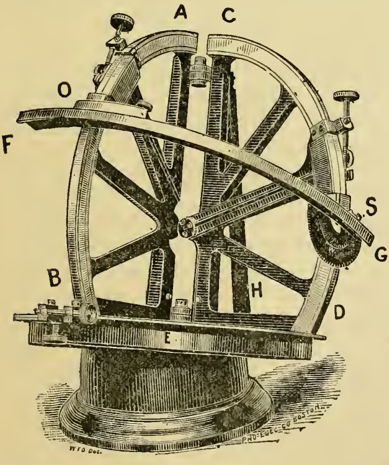
Nov. 13th, 1879.

LIEUT.-COMDR. A. D. BROWN, U. S. N., in the chair.

## ON AN INSTRUMENT FOR SOLVING SPHERICAL TRIANGLES.

By REV. THOMAS HILL, S. T. D.

About the year 1856 it occurred to me that an instrument for solving spherical triangles by inspection might be useful in navigation. But after some conversation on the subject with Professor Chauvenet, and others, I concluded that the saving of labor, effected by it, would not be sufficient to make it readily saleable, among navigators. The invention was therefore remanded to forgetfulness until 1873, when a paper, by Prof. Wm. A. Rogers, upon "The coefficient of safety in navigation," and an encouraging word from Prof. Benj. Peirce, led me to make a model, and show it to Mr. Cyrus H. Farley, of Portland, Me. He agreed with me in thinking that a ship with such an instrument on board, in the hand of one knowing how to use it, would in certain circumstances be safer; and after mature deliberation undertook the manufacture of what he calls The Nautrigon.



I had called it the Sumner, because I had received the first suggestion of its utility from T. H. Sumner's methods of using single altitudes.

The instrument, as manufactured by Farley, after many experiments in devising the most convenient form, is represented in the annexed cut. On a solid foot rests a plane, E ; the front edge of which is graduated as an hour circle, (of about 15 cm. radius) for about 8 hours, from D toward B. This plane makes an angle of about 25° with the base of the foot. Firmly attached to it, and supported perpendicular to it by the brace H, is an arc C S D of 120°, and 18 cm. radius, representing the meridian of the ship. Hinged to this is an arc A O B, of equal length and radius, representing the meridian of the sun, or other object. This arc carries a vernier, seen at B, by which the angle of the two meridians can be read upon the circle E.

The altitude arc F G is 92° in length, 2° below and 90° above zero, and carries at its zenith, G, a semicircle graduated as a compass card, and perforated at the centre, to receive a pin on the latitude vernier S. This altitude arc is free to be lifted off the pin at pleasure.

The spherical triangle most frequently used in navigation has for its vertices the elevated pole, the ship's zenith, and the sun.

Or if we consider the triangle as terrestrial, instead of celestial, we may say the vertices are the nearer pole, the ship, and the spot where the sun is vertical. In the instrument, the pole is between A and C, the ship is the pin on the vernier at S, and the sun's place is at the coincident zeros of the two verniers at O.

The arcs are graduated with sufficient accuracy to give the angles to the nearest minute, and the hour to within four seconds. For getting time from an altitude, and determining the ship's position by Sumner's method ; determining the time of sunrise and sunset ; getting the azimuth of a heavenly body from its altitude ; calculating the altitudes of the moon and star in a lunar distance ; and finding the course and distance, for great circle sailing, the instrument is all that is needed.

The two meridians have the same radius and same centre ; the altitude has the same radius ; but it is of no importance to have its center *exactly* coincident with the other centre.

The mode of using the instrument may be illustrated by the case of finding the time. An altitude of the sun is taken and corrected for refraction, semidiameter and dip. The ship's vernier, S, is clamped at her latitude ; the sun's vernier, O, at his declination. The altitude vernier at the corrected altitude. The altitude arc is then placed on

the pin, S, and the meridians swung into a position which will make a proper contact of the two verniers at O. The time is then read from the vernier at B. All this could be readily and carefully done, as rapidly as a man could write the directions.

Whereas to find the time by logarithms requires you to add together three angular measures; divide the sum by two; subtract one of the angles from this sum; find and copy out a function of each of the four angles thus obtained; add these four logarithms and divide by two; find in the tables the corresponding angle, and multiply it by two. All this requires much more time than the adjustment of the Nautrigon; it employs about seventy more Arabic figures, and gives at least eight or nine times as many opportunities for mistake; I should say sixteen or eighteen times.

Moreover at the same time that the vernier at B is showing the time, the compass card at G is showing the azimuth of the sun, so that if the azimuth was noted by the ship's compass at the time of taking the altitude, you have at once the compass error, (variation + deviation) without any additional labor of computation.

Capt. Sumner's method of using single altitudes was forced upon him by his peculiar position, when he had been storm-tossed several days in a fog, and had reason to fear he was near a dangerous coast. A sudden lifting, on the side toward the sun, gave him a horizon line; and enabled him to get an altitude which showed him on what circle his ship was lying. Fortunately for him the information, thus gained, was in time, so that he avoided the shipwreck which many other ships at the same time on the same sea suffered. But, under such circumstances, the five minutes saved by the nautrigon, in determining the position of the ship, might make the difference between safety and destruction.

The mate of a vessel on a passage from New York to San Francisco took an altitude on fifty-one different days, and determined the longitude, first by the nautrigon, then by five place tables; and in no case was the difference of the longitudes calculated by the two methods, as much as two miles; and in only four cases did it exceed one mile. Thus by the nautrigon he obtained, in each case, a speedy answer beforehand, by which he was assured of the accuracy of his computations; and thus increased the certainity of his position and safety of his ship.

Nothing can exceed the ease with which the course and distance, in great circle sailing, are obtained by this instrument. The ship's ver-

nier, S, is put on her latitude; the declination vernier, O, on the latitude of the desired part; the vernier B is set on the hour circle at the difference of longitudes; and the vernier on the altitude arc is brought to contact with O. The compass card now shows the course; and the complement of the denoted altitude is the distance. This operation is so easy that it may be repeated every few hours; and a steamer can thus save fifty miles distance in crossing the Atlantic.

Having thus obtained the great circle distance, you can, if you wish, determine the course more accurately in the following manner. Set the vernier on the sun's meridian to the complement of the distance; and the vernier on the altitude arc to the latitude of the desired port. Placing now the arc on the pin, and making contact of verniers, the required course is read to the nearest minute of angle on the hour circle. The compass card then marks difference of longitude.

In like manner we can obtain the azimuth of the sun, (when he is not more than 92° from the elevated pole) to a higher degree of accuracy, by setting the sun's vernier to his altitude, and the altitude vernier to his declination; the azimuth can now be read from the hour circle; and the compass card gives the hour.

These objections may be brought against the instrument.

First, its cost. The careful graduation of four arcs, and the careful adjustment of the centres of three of them on one line, and two of them to coincidence, is necessarily expensive. Yet if the nautrigon were furnished by the ship as a part of her equipment, the cost would be trifling to the ship owners, or to the government in vessels of the navy.

Secondly, the want of delicacy in its determinations. It cannot be made to read nearer than minutes of arc, without increasing greatly the cost.

But, on the other hand, it must be remembered that the indications of the chronometer, and measurements of altitude by the quadrant, and plotting of the ship's place on charts, embracing any large extent of sea, cannot be accurate enough to demand nice accuracy in the reductions. When a ship is so near danger that an error of one mile becomes important she does not depend on observations in the sky, she has land in sight.

Thirdly, the injury done to a navigator by diminishing his familiarity with trigonometry. This was the objection to the chronometer, but the chronometer came into common use. The navigator need not be compelled to unnecessary labor and anxiety merely for the sake of keeping up his familiarity with logarithmic formulæ. Sufficient op-

portunities will still occur for the navigator, even when he uses the nautrigon at sea, to make more accurate computations when circumstances favor more accurate observations than usual, in ports, or on smooth water with unusually clear air.

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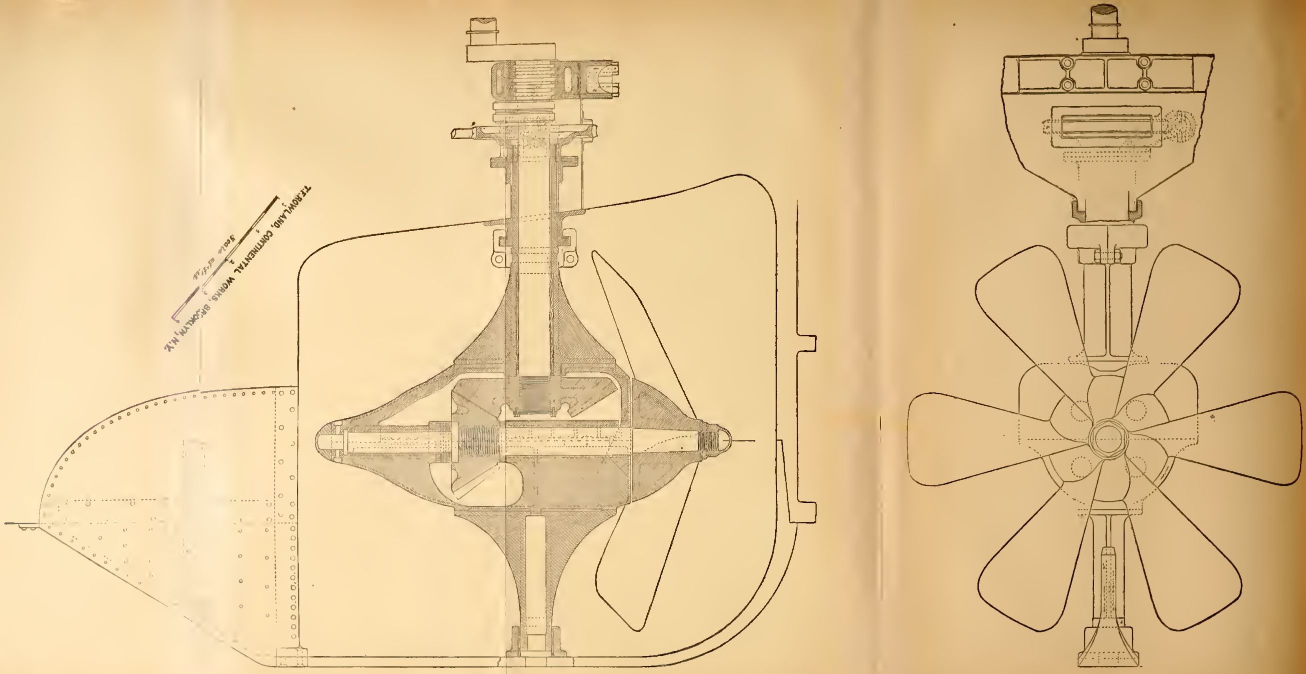
## DISCUSSION.

THE CHAIRMAN. My attention has been directed from time to time to the subject of the mechanical solution of spherical triangles: the Nautrigon presented for our consideration by ex-President Hill is in its essential features a reproduction of the armillary sphere of Ptolemy and of the celestial globe of Mercator. The phrase " use of the globes" is probably not unfamiliar to many of you: instruction in this branch of study included not only the method of using the ordinary terrestrial globe for such purposes as obtaining the latitude and longitude of any place, time of sunset or sunrise &c., but also the practice of the solution of spherical triangles by means of the celestial globe, which as I have just said, was in its main features not unlike the Nautrigon,of to-day. There is, in the Observatory here, a wooden model of an instrument based upon the same principles, the product of the skill in whittling of one of the graduates of this institution. Within the last three years there have also been received the working drawings of an instrument called the Automatic Navigator, the independent invention of another graduate. The great circle protractor of Professor Chauvenet, so well known in the service, is but another instance of the same idea of solving spherical triangles mechanically.

For the merchant marine I should think that the introduction of the Nautrigon would be of great benefit, as enabling the master of a vessel to find his position with considerable rapidity and with a very good degree of accuracy.

In the naval service, however. where one officer is charged with the navigating duties alone, I think its introduction as the chief dependence of the navigator would be of doubtful utility. An expert computer will, I think, as readily solve the ordinary problem of a time sight by logarithms, as by the Nautrigon. Still, I believe that for some purposes it would be an excellent idea if each vessel in the service were provided with one, as it might be useful in an emergency to obtain even an approximate position, as spoken of by the lecturer in the case of Captain Sumner. It might prove of use also in great circle sailing, and as Chauvenet's protractor is no longer in the allowance, this other instrument would take its place, besides being useful for other purposes.

I am very sure that you will join me in presenting the thanks of the Institute to the learned lecturer, for the ingenuity and care which he has displayed in the construction of the Nautrigon, and for the interest which he has taken in the improvement of the means of obtaining quickly and promptly the position of a vessel at sea.




MALLORY STEERING PROPELLER.

# THE RECORD

OF THE

# UNITED STATES NAVAL INSTITUTE.

NEW YORK BRANCH,

OCTOBER 16th, 1879.

Commander E. O. MATTHEWS, U. S. N., in the Chair.

## THE U. S. S. ALARM.

By LIEUT. R. M. G. BROWN, U. S. N.

The Alarm was authorized by an act of Congress, appropriating three hundred thousand dollars to build two Torpedo boats. Secretary Robeson put one under the charge of the Admiral of the Navy, who designed the Alarm; the other was put under charge of the Chief of Bureau of Construction, Isaiah Hanscom, who designed the Intrepid.

The object was to design a vessel that would assist in defending our coast from the attacks of any maritime enemy. The Admiral of the Navy determined to build the Alarm of iron, on the transverse bracket system, with a double bottom, and water-tight bulkheads every twenty or twenty-five feet. The objects to be obtained were, first, ability to fight bows on, and thus do away with all armor except on the bows; second, ability to carry one heavy gun to fire directly ahead, and to be trained by the helm.* Third, a ram so constructed that it would admit of striking the enemy below the armor. To accomplish this last point, the longitudinal frames of the Alarm were all made to meet at the extreme bow and then run aft, forming the heavy longitudinal bracing of the vessel. The keel was also doubled back so as to form the upper frame of the ram. This ram to be at the same time a casing for a long torpedo spar to run out thirty feet ahead of it; the ram itself to be cut off from the vessel proper by a water-tight compartment, so that should it suffer injury in ramming, and leak, no harm would be done to the vessel proper. Fourth, a system of torpedo bars to run out under

* The ease and accuracy with which a boat howitzer can be trained to fire directly ahead by means of the helm only, is an illustration of the advantage of a fixed carriage on such gun-boats as the Alarm.

water by steam power, the bow one to project thirty feet ahead of the ram, and the side ones seventeen feet from the side. These bars to be made of the best gun metal. The torpedo itself on the end of the spar, to open the outer valve, the inner valve being opened by a tackle before the spar was run out. These torpedoes to be connected to the firing machine by ordinary insulated wires, and so arranged that the commanding officer could fire them from any part of the spar deck. Fifth, an arrangement of water tight bulk-heads every twenty to twenty five feet, combined with compartments between the inner and outer skin so that the vessel could be sunk to any depth until the spar deck reached the water, and at the same time be provided with pumps of great discharging capacity so that she could be quickly freed of water should it endanger her safety. This arrangement of water tight compartments, also adds to the safety of a vessel, when rammed or injured from shot or shell.

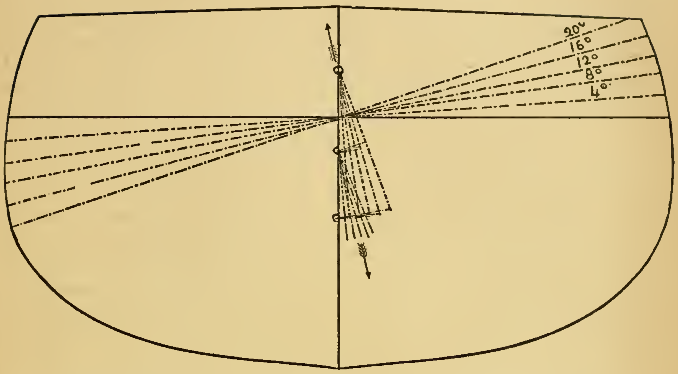
The Admiral of the Navy finally determined upon the present Alarm as embodying these essential principles and to some extent, carrying out the ideas he had obtained from the experience of the war, as one of the officers distinguished by success—the final criterion of every military and naval officer.

The Alarm is 173 feet long, 28 feet beam and 13 feet depth of hold, with a tonnage within the inner skin of 311 tons. The double bottom, when filled to the surface outside, will sink the Alarm 13 inches. Displacement 720 tons. Complement thirty-five men and five officers. The thickness of outer skin is one-half inch and of the inner skin three-eighths inch. The thickness of armor on bows is 4 inches, growing less as it comes aft. Thickness of wooden backing is 8 inches and of the steel deck under the plank deck three-eighths of an inch. She has twenty-five tons of ballast in the bows to trim her. She was designed to carry this weight as additional armor forward, but it has never been put on.

The battery, at present is one XV inch gun in the bows, which could be replaced by a 38 ton Krupp gun, by removing some of the ballast; and four Gatling guns on rail, which could be augmented to almost any number, or changed for a better weapon.

She has four boilers—Horizontal tubular type—each with a diameter of 10 feet, and length of 11½ feet. Internal diameter of tubes 3 inches, length 8 feet 8 inches. There is also a superheater. She has one telescopic smoke stack 45 feet from grates to top. She carries forty tons of anthracite coal in her forward bunker, and could carry twenty-five tons more in the compartments between the skins on each

U. S. TORPEDO BOAT ALARM.




*Cross section through frame* ⊕ SCALE, $\frac{1}{2}$ inch = one foot.

Mean Draught of Water, 10' 6"

| | | | | |
|---|---|---|---|---|
| Displacement to " " | | | 745 tons. | |
| Centre of Buoyancy below Load Line, . . | | | 4'.33 | |
| Meta centre above Centre of Buoyancy, . . | | | 6'.08 | |
| Centre of Gravity below Meta centre, . . | | | 3'.25 | |
| Statical Stability, . . . | 4° | Inclination, | 186.25 | ft. tons. |
| " " . . . | 8° | " | 357.60 | " " |
| " " . . . | 12° | " | 506.60 | " " |
| " " . . . | 16° | " | 670.50 | " " |
| " " . . . | 20° | " | 849.30 | " " |
| Approximate Dynamical Stability, | 4° | " | 5.90 | " " |
| " " " | 8° | " | 23.56 | " " |
| " " " | 12° | " | 52.90 | " " |
| " " " | 16° | " | 93.80 | " " |
| " " " | 20° | " | 146.02 | " " |

side of the boilers. This would be a considerable protection to the boilers. It would only be necessary to cut a door from these side compartments into the fire-room, and a deck scuttle from the spar-deck to adapt these bunkers to use.

A Horizontal tubular boiler,—a launch boiler,—is on the spar-deck for heating the ship, and for exercising spars and gun, when steam is not up on the main boilers. The area of grate surface is one hundred and sixty-eight square feet, and of heating surface four thousand three hundred and sixty-nine square feet, being as one to twenty-six, but including the superheater the proportion is one to thirty-one.

She has horizontal compound engines, two high pressure cylinders with a diameter of twenty, and two low pressure cylinders with a diameter of thirty-eight inches. The stroke is thirty inches. The air and circulating pumps are independent of the main engines. The surface condenser has a cooling surface of one thousand six hundred and seventy square feet. She has an indicated horse-power, burning ordinary anthracite coal, of eight hundred, which can, by burning Cumberland coal, be augmented to one thousand horse power. I refer to Chief Engineer Isherwood as the authority for this statement. Her maximum statical stability is 31° when drawing ten feet six inches of water and taking into consideration her rail. If the rail is not considered, but only the height of the spar-deck above the water line, four feet six inches, it is 19°. Her stability will be even greater by the substitution of the Mallory propeller for the Fowler wheel.

The accompanying tracing of her midship section, for which I am indebted to Mr. Jackson, the chief draughtsman of the New York Navy Yard, shows the excellence of her model and the difference between her statical and dynamical stability, or in other words her ability to right herself in a seaway. It would doubtless add to her efficiency as a gunboat if the present armor and backing were removed, and five inches of compound armor, made according to the recently discovered method, were substituted. It would cause any projectile fired from directly ahead to glance off, owing to the acute angle formed by the armor. The experiments in England will, I think, fully bear me out in this assertion. It is almost impossible to pierce armor, even when very light, if placed at an angle of 35°, or less, with the direction of the projectile. This armor on the bows would protect the whole vessel as long as she was fought bows on. It is true that a shot from either side would disable her; but it is not to be presumed that any one would undertake to fight a fleet with a single gun-boat. When a

large number of such gun-boats were assembled together they would have to be manœuvred as regiments are now, that is in such a manner as to protect their flanks and rear.

During the recent extra session of Congress an appropriation of twenty thousand dollars was made to change the Fowler wheel formerly on this vessel to the Mallory steering propeller. This change will soon be completed. The new propeller is attached to the old engines, no change of hull being made except to put on a skeg below the keel, so as to allow for a propeller of sufficient size. The new propeller is geared to the old vertical shaft, it being cut off five feet below the stern bearing, and a horizontal wheel fitted to it. This horizontal wheel is fitted with a bevelled gearing to a vertical wheel on a horizontal shaft, to the other end of which is affixed the screw propeller. Both wheels are surrounded and protected by a casing which also affords bearings for the horizontal shaft, the upper part of casing forming a sleeve to the shaft (vertical) of engines, and so carried up into the vessel that it can be turned by an auxiliary or steering engine; thus the whole casing and horizontal shaft carrying the propeller can be turned about the vertical shaft in any direction. This enables the commanding officer to steer the vessel with the same facility as the Fowler wheel enabled him to do, and at the same time the speed of the vessel, when going ahead, is about the same as with the ordinary screw. In fact the gearing for the Alarm is so arranged that sixty-six turns of the engines, will turn the propeller ninety-nine times. The propeller has a diameter of ten feet and a pitch of fifteen feet, with six blades. It is hoped that the engines will be able to run sixty-six turns as a regular speed, making the propeller travel about fifteen knots, and, allowing 20 per cent. for slip, the vessel about twelve knots.

The accompanying tracing shows the gearing of the Mallory steering propeller. The inventor claims that with his propeller he can get as great speed in small gun-boats as with twin screws; for he can have a propeller of greater diameter than the diameter of the twin screws, and he will obtain much greater steering facility. It is probably not quite as effective for speed as a single screw of the same size making the same number of revolutions, as more slip is to be expected on account of the casing always being in front of the propeller.

That the Mallory propeller will prove valuable in small gunboats its friends feel confident, although of course all experiments are liable to failure. The fact that a very economical Congress appropriated the necessary funds would indicate that they held the opinion that the

government of the United States was able to ascertain for itself, the value of this, an American invention. The English government is fitting it to three small vessels, the largest one hundred and twenty feet long; but it is hoped that the Alarm may be ready for trial first.

The great interest taken by our own and foreign officers in this patent shows the necessity of some propeller that will enable gunboats to fight bows on, their guns being on a fixed carriage. Of course no private firm can carry on such experiments, besides there is no use for such propellers except for war purposes. It is therefore idle to say that we should wait until other people try such patents. If this does not succeed no time should be lost; but other inventors should be encouraged to design a propeller to accomplish the end desired, that is a propeller which allows the *whole energy* of the main or driving engines to be instantly used for steering purposes, and then be instantly restored for driving purposes. The advantages of such a propeller were thus described by the writer in an article of Apr. 4th, 1879, in the Army and Navy Journal. "The advantage would be that, the guns being mounted forward, all the fighting ability of the vessel could be exerted at once, being concentrated in the same direction, without exposing the broadside to the enemy at all. Two guns on the bow would give a battery equal to the single turretted monitors, and a double deck and four guns would give one equal to the double turreted monitors. Then that great auxiliary, the ram, would be ever ready for use, while it would almost secure the vessel from being rammed by the enemy. Fighting bows on, would also be the most favorable for the use of torpedoes, when using either a bow spar or side spars, or when discharging them from tubes under water. The means of attack and defence would all assist each other;—at the greater distance the guns, then the torpedoes, and finally the ram. Very little of the vessel would be exposed to the enemy's fire, and that part could be heavily armored, and, owing to its shape, could easily be made invulnerable."

Since writing the foregoing article the firm of Sir Wm. Armstrong & Co., have built the Epsilon, Theta, Eta and Zeta gunboats for the Chinese government. These are of steel to save weight, carrying one 35 ton gun, fitted on a permanent carriage, as on the Alarm, and with Gatling guns on the rail as on the Alarm. They have four hundred and forty tons displacement, being one hundred and twenty-seven feet long, twenty-nine feet beam, and nine feet six inches depth. They have twin screws, which can steam ten knots ahead and nine astern.

The English Admiralty have recently authorized the construction

of the Polyphemus. The principles and design bear a great resemblance to the Alarm. The leading features are a strong ram, a powerful torpedo battery, and small surface exposed to the enemy, with speed and handiness. She is to have the side compartments fitted to carry coal.

The same idea of getting invulnerability by having her armor so arranged that the enemy's projectile must strike at a very acute angle, has been adopted. She will have a convex armored deck of steel four and one half feet above the water line and three inches thick. This will give her the same protection, no matter from where the projectile comes, but it prevents her from carrying a battery. She is to discharge her torpedoes from tubes under water but as the genius of Ericsson has not yet solvèd that problem satisfactorily, I doubt if her torpedo system is as good as that on the Alarm. In fact I conclude that she is nothing but a ram, which, owing to her size, can have great speed. But great speed and twin screws do not give ability to strike with certainty. A vessel with a propeller having the steering ability claimed for the Mallory, and a much inferior speed would be able easily to dodge her blow, and would have a chance to damage her with gun, ram and torpedoes as she passed.

The Alarm, considered as an experiment, is a remarkable exception in being so free from the faults necessarily attending the practical developments of new ideas. It is true she never possessed speed—a very necessary thing for a gunboat, and a torpedo boat,—but as far as carrying her battery and the working of the torpedo spars is concerned, nothing better could be desired. Mr. Reed, late Chief Constructor of the Royal Navy, expressed his astonishment at the facility with which the torpedo spars worked.

It can also be said of the original Fowler wheel that while it did not attain the speed claimed for it by its inventor, it fully came up to his expectations in steering power. His later improvements of the same wheel are said to give a very good speed. It is to be regretted that petty jealousy and personal feeling has caused a few officers to speak disparagingly of a vessel, which is certainly the forerunner of what is to prove a very valuable type of war vessel. As a rule I have found them extremely ignorant of the facts in regard to which they so freely expressed opinions. Nor can I limit this severe remark to any corps or branch of the service. That her hull is a very fine one, and in very good condition is a fact apparent to any one not determinedly blind. That most of the new ideas of which she is the exponent are by her shown to be

feasible is also clear. The fact that her engines were defective no more condemns a steam vessel than the necessity of a new suit of sails condemns a sailing frigate.

The determination of the Admiral of the Navy to test the Fowler wheel was not made without due consideration. The idea of fighting bows on required a propeller of great steering ability. Twin screws do not give it, for while they enable a vessel to turn short round it is at the sacrifice of time; besides, in vessels of small size, it is almost impossible to get twin propellers of sufficient size to give good speed. It was then apparent, as it is now, that we needed a propeller, that, while it retains the speed of the single screw, will give in addition great steering qualities.

The Fowler wheel was urged upon the Admiral of the Navy, as a patent worthy of trial. In referring to the records of that time I find that several trials and reports were made upon the Fowler wheel, most of them favorable. One report by Passed Assistant Engineer George W. Stivers, who was sent to Philadelphia by Chief Engineer Wood to try and report on this patent, shows a speed of 9.89 nautical miles, the boat (the Frank G. Fowler) being seventy-three feet long, fifteen feet beam, and five feet draft. The distance run, half with and half against the tide, was 3.75 knots. Although he does not give the slip, it can be easily calculated from the data of his report and is only 3.3 per cent. This was in accordance with the claims of the inventor. That the real slip was more than ten times that amount the experiment of the Alarm has proven.

I find that Chief Engineer Stimers was an advocate of trying that propeller, and estimated that about half the boiler and engine power now in the Alarm would drive her thirteen knots, the speed desired with the Fowler wheel. Chief Engineer Wood also suggested certain changes which he thought would enable the Fowler wheel to drive the Alarm thirteen knots. He also fixed the angles of the blades of the Fowler wheel, I presume in accordance with the ideas of Mr. Fowler. The engines and boilers were put in under contract by John Roach and Sons under the superintendence of Chief Engineer Henderson, and Assistant Engineer Stivers. The boilers are excellent and have never given any trouble. The engines however were never properly secured in the ship. They have been resecured, and the next trial trip will, I think, demonstrate that they have now been properly fastened in the vessel. They will then at least have a fair trial, which they never have had heretofore.

It is to be regretted that officers should, for personal reasons, disparage experiments for the benefit of the service. When, last winter, by the authority of the Department, I asked the Naval Committee of the House of Representatives to appropriate twenty thousand dollars to try the Mallory propeller, informing them at the same time that it was only an experiment and therefore might prove a failure, I was surprised to know what bitterness had been expressed against the Alarm. A very able Engineer Officer wrote to a member of the Naval Committee, and one to whom I am chiefly indebted for the appropriation, that the Alarm was a miserable failure in every respect, and that the hull, the machinery, and the Fowler wheel alike were only fit for the scrap heap. Chief Engineer Isherwood, on the contrary, says in a recent letter that Admiral Porter's idea of the requirements of a torpedo boat was quite correct, and the Fowler wheel, which at the time was the only apparatus known which could give the steering and reversing qualities essential to the Alarm, had not been experimentally shown to be deficient in speed.

That the hull of the Alarm is an excellent one and that she was thoroughly built, of the best iron, is the opinion of every Naval Constructor and expert who knows anything about her. She was modelled by the most distinguished Naval Constructor the Navy has possessed for very many years. Her hull is in good condition, nearly as good as the day she was launched, and unless accidentally sunk she will out-wear all the officers who have so summarily condemned her.

It has frequently been stated that the Alarm has cost a fabulous amount of money. This may be true on paper as she has been in commission for several years, and most of the time at one of the navy yards; consequently, as some changes and repairs were frequently being made, it is not unlikely she suffered from being a convenient place to charge work which could not well be charged elsewhere. This custom fortunately is not so popular at present as it was formerly in the Service. But as her hull was built by the Naval Constructors of the New York Yard, and her machinery was put in under the direction of Naval Engineers, neither the Alarm nor her designer can be blamed for the bills. It should not be forgotten however, that she was the first iron vessel ever built at the Navy Yard, and that consequently the Constructor's skilled workmen had to learn anew the art of ship building. They finally succeeded in building a very strong vessel, but of course they could build a second one at very much less expense.

In regard to the engines they were designed to suit the Fowler wheel,

and put in by contract by John Roach & Sons. The Engineer superintending the work made frequent reports as to the progress of the work and found no fault with the way it was being done. It is true it would probably have done no good had he protested. When the writer took command of the Alarm a little over a year ago, it had been fully decided that she was unfit to go to sea with the Fowler wheel. Being a firm believer in the usefulness of such a type of vessel, and feeling that the Alarm was all that could be desired as far as hull, torpedo machinery and boilers were concerned, he consulted with the present Engineer-in-Chief of the Navy, as to the best means of making her efficient. Sometime before that officer had ordered a board, consisting of Chief Engineers Isherwood, King and Warton, to report on the merits of the Mallory propeller. The report of the Board, Chief Engineer King dissenting, was in favor of a trial of the Mallory wheel. They recommended that it should be fitted to the United States torpedo boat Alarm, for the following reasons: 1st. The Alarm is a small vessel, and there is little doubt of success in the application. 2nd. The Alarm is a large enough vessel to give the Steering Propeller a very fair practical test, enabling both its capabilities and endurance to be well ascertained before any application of it to a larger vessel is attempted. 3rd. The Fowler wheel, with which propelling instrument the Alarm is now fitted, is confessedly very unsatisfactory as regards speed of vessel attainable with it, compared to the speed attainable with a screw driven by the same engine-power; in fact about three times the power required with the latter is required with the former to produce the same speed of vessel. The Fowler wheel, though well adapted for steering and manœuvring vessels, is much inferior even in these respects, to the steering propeller; and its complicated mechanism is designed on such fallacious principles that improvement is impossible. It should, in any case, be removed if service is expected from the vessel. 4th. The Mallory steering propeller can be placed in the precise position now occupied by the Fowler wheel without any changes in the stern of the vessel, or in the motive engines; the vertical male and female shafts of the steering propeller going exactly through the hole in the counter where the vertical shaft of the Fowler wheel now passes. A deepening of the keel aft is all the addition needed. 5th. The only cost of applying the steering propeller will be the expense incidental to removing the Fowler wheel and manufacturing and installing the steering propeller in its place. This plan is the very cheapest possible by which the Alarm can be

rendered efficient. It leaves the hull and motive machinery intact, and has the additional advantage not only of preserving but increasing in a large degree that power of perfect steering and manœuvring which the distinguished designer of the torpedo boat considered indispensable for such vessels, even if it had to to be obtained at the expense of other valuable qualities. By the substitution of the steering propeller the original design of the vessel, so far from being changed, will, in fact, be perfected. 6th. If the proposed substitution of the steering propeller for the Fowler wheel be made, it should be subjected to long and accurate experiments, the importance of the improvement to the Navy warranting, in our opinion, a liberal expenditure for a thorough test.

The old engines of the Alarm were anything else but satisfactory, but as they were of a type suitable for a trial of the Mallory wheel it was thought that they could be repaired so that they would at least be of sufficient efficiency to determine the value of the patent of Mr. Mallory.

Congress was asked by the Honorable Secretary to appropriate twenty thousand dollars for this purpose. The committees having heard a full statement of the possible merits of the invention, decided to appropriate the money, which was accordingly done. It is the expectation that the Department will order a thorough trial of this patent. If it succeeds it will be a very valuable propeller for torpedo boats, rams, and gun boats; if it fails no harm will be done, save the trifling expense, as the hull of the Alarm has not been altered nor injured. Should the experiment prove successful it would seem to me very desirable to build a number of gunboats. They would be extremely valuable, in case of emergency, for the defense of our shallow coast, and during peace times they would be able to perform duty on rivers and inland seas both at home and abroad. If built of iron on the transverse bracket system, with a double bottom and sheathed with wood, the planking being in two layers, one of three inches in thickness and the other of two inches, so as to prevent all danger of galvanic action between the iron of the vessel and the outside copper, they would last for thirty years, only requiring replanking every few years. They would afford a cheap and excellent platform for one gun of large size. The excellence of the platform results from the fact that the gun can be placed in the line about which the vessel rolls, so that pitching is the only motion of the vessel that interferes with accurate firing. This gun being on a permanent carriage, would be easily handled, and as it would always be pointed towards the enemy, would admit of very rapid firing.

When we take into consideration the difficulty of turning a monitor's turret, and the fact that the vessel also has to be manœuvred, as a general thing, in order to obtain proper aim, I am inclined to believe that one gun mounted on a gunboat like the Alarm would be as efficient as the two guns of an ordinary single turretted monitor.

The service is indebted to a very distinguished officer for demonstrating the great importance of the ram in attack. But the vessel proposed by Admiral Ammen has a speed of only 13 knots, and no other means of attack excepting the ram. His proposed vessel is to be built on the transverse bracket system, with heavy longitudinal frames as in the Alarm. In comparing the two vessels the same master hand in Naval Construction appears. The ram on the proposed vessel of Admiral Ammen is to strike two feet below the water line instead of below the surface as in case of the "Alarm." I must say that I consider the latter plan the better as the last vessels constructed for the Royal Navy carry their armor several feet below the water line, and the turtle-backs being constructed for the Russian navy have a sharp edge at the water line, on purpose to prevent injury from a vessel striking near the water line. Besides there is an advantage in the ram's running well ahead of the vessel as on the Alarm; it better enables a vessel to carry her gun and the armor necessary to protect her hull above water. Water-tight bulk-heads can easily be arranged so as to prevent the entire ram from filling when injured.

As the proposed ram of Admiral Ammen is only to carry three inches of iron on the turtle back principle, I can see no advantage over the same thickness of iron in a vertical position and equally inclined to the line of fire of the enemy. I therefore conclude that vessels designed on the general plan of the Alarm, would, with equal speed, be equally as valuable for ramming. The same speed with the Mallory propeller would make the Alarm infinitely superior.

In regard to the torpedo system fitted to the Alarm, I know of nothing better at the present time for vessels of her class. I confess I think this method of attack has been much over-rated. When there was a superstitious dread of the name *torpedo*, it was more effective from that fact, and from the terror caused by the exploits of a few men like Cushing, than from the actual damage done. That they are and will remain a great weapon for harbor defense is, I think quite certain, but for vessels like the Alarm designed to carry a gun of the largest size, and having a powerful ram, I doubt if they hold the first place in her means of attack and defense. This condition of af-

fairs will be changed as soon as we are able to discharge them from tubes or guns under water. Captain Ericsson is now engaged upon the solution of this problem. Until such a method is perfected her arrangement is undoubtedly the best. Of course I do not compare her with such vessels as the Destroyer and Lightning intended only for harbor work.

That such a type of vessel as I have advocated is peculiarly adapted to our present situation is, I think, beyond dispute. Even if the Department desired to build enormous iron clads it is not probable that Congress would grant the money. And I hope I am not presuming when I state, that in my opinion, both the Department and the Service is heartily tired of repairing old wooden vessels at enormous cost only to make one cruise and then go under repairs again.

## DISCUSSION.

Comdr. COTTON. When the double bottom of the Alarm is filled, what is the distance of the deck above the water?

Lieut. BROWN. About 3½ feet; but water can be admitted to sink her to any depth.

Lieut. WEST. How long does it take to sink the Alarm to fighting trim by filling the compartments?

Lieut. BROWN. About half an hour to sink her three feet, but it must be remembered that sinking a vessel interferes with speed and handiness. The probable service would of course determine how far to sink her.

Lieut. WEST. As the force applied to turn the propeller is carried through a system of cogs, is it known from any previous data of smaller Mallory wheels what is the element of weakness in the cogs?

Lieut. BROWN. The gearing wheels are made of the best phosphor bronze, and after careful calculation were made amply strong to transmit all the power possible to develop.

The CHAIRMAN. There are several things I would like to ask: first, Whether the strength of the cogs of the Mallory system has been calculated to stand the strain brought on them by the driving engine only, or when the driving and steering engines are acting in opposition? It would seem to me that there would be a very great strain upon the horizontal steering wheel, or worm wheel, especially when steering against the motion of the propeller. If the auxiliary rudder should be fitted would it not necessitate an extension of the keel, in order to permit the rudder to revolve freely around its axis?

Lieut. BROWN. The strength of the cogs is ample when revolving the same or different ways. The steering engine is only 50 horse power: the strain can never exceed the horse power of the steering engine, and it is amply strong to stand that. It has no connection whatever with the main engines. An extension of the keel would not be necessary, only an ordinary rudder has been suggested, fitted to the old gudgeons of the rudder post, exactly as it was with the Fowler wheel.

Civil ENGINEER PRINDLE. Is it claimed that less horse power is required to drive the propeller under the Mallory system than under the other systems?

Lieut. BROWN. It will require a little more power, owing to the gearing. The advantage is simply the steering facility.

Lieut. WEST. When on board the Alarm on her trial trip down New York Bay, I noticed the vibration of the ship to be great when working up to full power. Is it known whether the Mallory wheel compares favorably with the Fowler wheel in this respect.

Lieut. BROWN. That vibration was caused by the engines being improperly secured, and by the fact that only one of the four blades of the Fowler was exerted at any one time to drive the vessel. It is expected to entirely do away with vibration, by securing the engines properly, and from the fact that the new propeller is an ordinary screw with six blades.

Comd'r. COTTON. Would it not be an improvement in the Alarm to have the Pilot House forward clear of obstruction?

Lieut. BROWN. It undoubtedly would be better to have one there also. I have recommended that to the Department. If it was like a turret it would be a great protection to the chimney and after pilot house when fighting bows on.

Lieut. WEST. In that connection I would say that Captain Ericsson's torpedo boat, the Destroyer, is steered from forward, not having a pilot house proper, which would expose more surface to an enemy's fire, but from sighting holes nearly level with the deck forward, which is flush and clear of obstructions. The movement of the steering wheel is carried aft on either side of the vessel to the run by light wire ropes. At the run is an

hydraulic engine gear which is controlled by the wire ropes, and the engine acts on the tiller of the rudder of the vessel. Could not such power be applied advantageously to the steering sleeve of the Mallory wheel?

Lieut. BROWN. The Alarm can readily be fitted for steering from any place forward. It would only require a light wire rope for working the Stephenson link of the steering engine, and an indicator for showing the position of the screw shaft or steering sleeve. The rotary motion could be given to the sleeve by hydraulic machinery, but it would be no improvement over the present high speed steam engines in point of efficiency and simplicity.

Lieut. HANFORD. I should like to ask what torpedoes are used on the Alarm, and how they are attached to the spar? What effect has the explosion on the spar, and what effect will the additional speed expected have upon the spars?

Lieut. BROWN. The torpedoes are in shape not unlike an ordinary elongated projectile, having the outboard end hemispherical. Those for the bow spar are four and one-half feet long and a foot in diameter. Those for the side spars are not so long. The end of the spar enters the end of the torpedo shell for about a foot, there is then a space of about six inches for water to act as a cushioning, then a diaphragm with an opening in center, for the water tight fitting fuse. The rest of the torpedo is filled with the explosive. The explosion jars the spar considerably and makes it recoil a very little. Passed Ass't. Engineer D. Jones, at my request calculated the strain at 12 knots. From his conclusions I do not fear carrying them away.

The chairman, in closing the discussion, spoke of the paper and discussion as being a most interesting one, and, as a fuller examination of the subject would lead to a more extended discussion, the consideration of the subject was adjourned until the next regular meeting of the Branch.

The thanks of the Branch were extended to Lieutenant Brown for his valuable and interesting paper.

# THE RECORD

OF THE

# United States Naval Institute.

NEW YORK BRANCH,

Nov. 20th, 1879.

Chief Engineer H. L. Snyder, U. S. N., in the Chair.

## THE DEVELOPMENT OF ARMOR AS APPLIED TO SHIPS.

By Lieut. Jacob W. Miller, U. S. N.

Mr. Chairman and Gentlemen:—

The progress of the past century is in no instance more marked than in the development of naval architecture. In this development—as in all kindred onward efforts—the advance has not been a steady one, but mingled with many retrograde steps, which at times have seemed to endanger the attainment of its object. That object I hold to be the construction of the most effective war vessel. By a careful study of the various means taken during the past to accomplish such a result the type of ship necessary to fight the battles of the future may be discovered. While leaving this broad subject to those whose talents and energies may have fitted them to deal with it, I propose to limit myself in the following pages to the history of armor as applied to naval vessels, and to briefly discuss the important lessons which it teaches.

The history of armor may be divided into three epochs.

I. The Theoretical, which extends from the first use of artillery on board ship (1350), to the year 1842, when Ericsson gave the world a screw-man-of-war, armed with a wrought iron gun.

II. The Experimental, which begins at this date, with the introduction of iron naval-ship-building, and ends with the first iron-clad engagement at Kinburn, in 1855.

III. The Practical, extending from 1855 to the present time.

I. I have termed this period the Theoretical; but I would not have it understood that no experiments took place prior to 1842. Attempts there certainly were to cover vessels with defensive plates, but these attempts as a rule began and ended in plans proposed by va-

rious inventors, and never resulted in the completion of a sea going armor clad.

The first authenticated propositions for metallic armor date no further back than the beginning of the present century, yet as a matter of curious research it may be of interest to look into the work of one Giacomo Bosio, published in 1612, where we shall find a description of the great karrack Santa Anna, a vessel of seventeen hundred tons, built at Nice in 1530 for the knights of St. John.* "She had six decks of which two were under water, all were sheathed with lead, and bolted with brass, which does not consume lead as iron does, and thus constructed it was impossible to sink her, although all the artillery of a fleet were fired against her. Her huge main-mast was made in pieces, and of such size six men could not embrace it. * * * She was never pierced below the bulwarks. * * * * * She was entirely sheathed with lead from the bulwarks downwards, and below the water line bolted with brass bolts." Then follows a description of ovens for baking fresh bread, of an armory for five hundred pieces, of forges for three master blacksmiths, and of many other novelties; showing that in naval architecture, as in all the other arts of war, the knights of Malta were far ahead of their day.

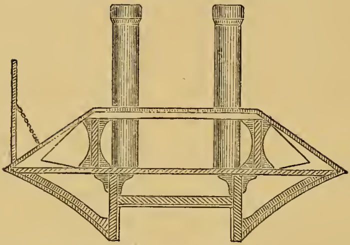
At the siege of Gibraltar, 1782, the French and Spaniards employed floating batteries made by covering the sides of ships with junk, raw hides, and timber. The largest of these vessels was fourteen hundred tons and carried a battery of thirty-two pdrs.

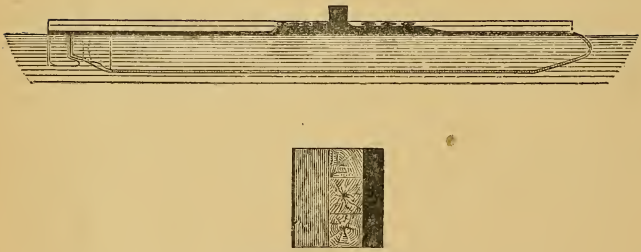
In 1813 Fulton constructed a floating battery for the United States government; and, as early as 1814, Thomas Gregg of Pennsylvania patented a "ball proof-vessel." Gregg's design embraced a flat upper deck, from which the sides and ends sloped outwardly to the water line, where the upper part of the vessel was very broad, overhanging the submerged portion, and protecting the rudder and means of propulsion. The gun deck was nearly level with the water line, and ports were cut in the inclined sides. She was to have been covered with copper or iron. About this time the elder Stevens began a series of experiments at Hoboken, New Jersey, which led him to the same conclusion regarding the merits of inclined sides.

* Metal shields were used during the earliest centuries of the Christian era, as a protection for the upper works of a ship. The Normans placed iron casings over the water line during the twelfth century, and it is said that Peter of Arragon had an iron plated ship.

Plate I.

Gregg's ball-proof vessel 1814.





Stevens' battery 1861.

During 1821, Colonel Paixhans recommended armor for ships as worthy the consideration of the French admirality; while England tried the effects of shot against masonry covered with iron, at Woolwich, in 1827. India rubber was also proposed, as sheathing for a seventy-four-gun ship, but whether for the purpose of resisting shot or the action of sea water I am unable to discover. Eight years later a series of trials took place at Mentz against forged and rolled iron.

The United States, profiting by the foreign reports, experimented upon a laminated target of sixteen quarter inch plates; through which Commodore Kerry fired an eight inch shot at Sandy Hook, in 1837. This target, five feet high, and two feet nine inches broad may, I think, still be seen at the New York navy yard. The failure of this plate did not convince the naval committee of 1841 that four inches of iron was too thin to resist projectiles, and a contract for a vessel with that thickness of metal was given to R. L. & E. A. Stevens, on the 10th. February, 1843. When Commodore Stockton, the following year, demolished a four and one-half inch iron target with a two hundred and twenty-four pound shot, Stevens increased his armor over two inches in thickness; and a second contract was made. By the terms of this contract the Stevens Battery was to have a length of four hundred and twenty feet, a beam of fifty-four feet and a draft of twenty-six feet; she was to be fitted with water tight compartments, and armored to four feet below the water line. Her sloping sides were to be covered with 6.75 inches of iron, backed with fourteen inches of wood. Her beams were to be made of six inch wrought iron bars. Her guns were to fire en barbette, and to be loaded below decks. That this vessel was never completed was no fault of her original designer; and in the disputes which followed between the contractors and the government the fact was forgotten that Stevens, as well as Gregg, gave to America designs for armored ships, containing the germs of almost all the systems which have since been claimed as original by foreign constructors.

For twenty years prior to this time another great brain had been at work, evolving many inventions. Prominent among them were two which were brought into practical operation, during the year 1842, in one vessel; and when the U. S. S. Princeton, propelled by Ericsson's screw, and armed with Ericsson's wrought iron gun was launched the war between armor and projectiles began. Heretofore the means of propulsion by steam had been by machinery entirely above the water, and exposed to an enemy's fire; the screw did away with this

great drawback, removing the working beam and paddle, compact engines in the hull, giving motion to a propeller protected in part by the element in which it acted. The center of gravity was also lowered, and, the paddle boxes being removed, there was less surface to armor, and less target to hit. We now come to the

II. or Experimental Period. The Princeton was in reality Ericsson's first monitor, giving a warning, on both sides of the Atlantic, of the changes that were to ensue. Congress resounded with eulogies of the genius which would enable us in the near future to defy the navies of Europe. Parliament, perceiving the error the admirality had made in driving the Swedish inventor from England, voted large sums of money to build trial propellers and built-up guns. The British foundries were ready for the emergency; stimulated by the success of their first iron steamers, they hastened to increase their plant so as to include the fabrication of armor plates for iron men-of-war. The age of iron had begun. Fairbairn and Lord Ross were standing sponsors for infant plates of three and four inches, which others vainly strove to kill with heroic doses of thirty-two pound shot. Rival metals were also asserting their claims as a means of defence, and General Totten writes in 1853 that, "next to wrought iron lead concrete proved the best material, as it will not crack nor splinter, heavy shot molding for themselves a symmetrical bed in which they are found crushed; their effect being local." The increase in the calibre of the new guns, and the consequent necessity for a thicker metal for a ship's defense, rendered the use of lead impossible; while the four and one-half inch iron plates, experimented upon at Portsmouth in 1850, still resisted the sixty-eight pound shot.

Four years later the Emperor Napoleon received a letter from Ericsson presenting a plan for a novel vessel; but even scientific France was not ready to adopt the radical changes suggested by the inventor, and the "cupola ship" was kept for that March day of 1862, when the world was forced to acknowledge the value of a "vessel with armored sides protected against shot by being submerged in the water, thus securing buoyancy and protection at once." Reference to Ericsson's contributions to the Centennial Exhibition will show that his design of 1854 was in all essentials similar to the later Monitor of 1861, and that the turret was something more than a stationary shield or cupola; one of the main features being the *concentration* of the battery. I am thus particular in enumerating its distinctive characteristics, for, in the following year Captain Coles of the English

navy proposed mounting a number of conical cupolas on the deck of a high sided, rigged ship, of the usual form, and even as late as 1862 he sent a model to the great exhibition with five cupolas. During those seven years—from 1855 to 1862—Coles wrote many articles and lectures on the merits of his system, in none of which can I find any allusion to the name of Ericsson, perhaps for the reason that he saw the many differences between their two plans. Captain Coles' sad fate would naturally lead us to overlook any omission to acknowledge Ericsson's previous invention were it not for the fact that his friends have claimed that the cupola and monitor turret were identical. Besides there was a man in the United States who, eleven years before, had placed drawings in the patent office, of "Timby's turret," and his right of invention was long after recognized by the government.

The Crimean war was now calling forth all the energies of the Allied Nations. France, especially, was busy constructing floating batteries covered with four and one half-inch plates. The hulls of these vessels were of wood; and the iron plates three feet long, and twenty inches wide. On the 17th of October, 1855, they received the fire of the Russian forts at Kinburn. The following particulars are from Commander Dahlgren's account of the action:—"The French floating batteries Devastation, Lave, and Tonnante, steamed in to make their first essay, anchoring some six or seven hundred yards off the S E. bastion of fort Kinburn. * * * * The Russians could only reply with eighty cannon and mortars, and no heavier guns than thirty-two pounders, while many were lower. * * * This was the sole occasion in which the floating batteries had an opportunity of proving their endurance. * * * They were hulled repeatedly by shot, and one of them—the Devastation—it is said sixty-seven times, without any other effect on the stout iron plates than to dent them at the most one and a half inches; still there were ten men killed and wounded in this battery by shot and shell that entered the ports."

This first engagement of iron-clad vessels ended the experimental era. The immense advantage derived from an armor-shield was established by the rough ordeal of war. It was useless to argue that the ordnance brought to bear against the batteries was of small calibre, for heretofore it had always been held that guns of inferior dimensions, planted firmly on land, were more than a match for much larger ones mounted upon a floating, unsteady platform.

Two other facts went far about this time to convince the naval world of the necessity of providing against the destructive effects of

shell firing. One was the annihilation of the Turkish fleet at Sinope in 1853; the other the arrival of the United States frigate Merrimac, on the Mediterranean station, with her tremendous battery of IX inch Dahlgren guns. Shells were beginning to be used as mines instead of missiles; it became essential to find some material stronger than wood to keep them from entering the ship. The three French batteries of Crimean fame were not equal to the task; and their five English imitations were too unwieldy to accomplish the result. Let us see how the emergency was met in the

III. OR PRACTICAL PERIOD. Thus far I have treated the subject historically, merely dwelling upon certain points calculated to illustrate the important part played by America and France in the earlier development of armor. To follow the successive steps of this development from the year 1855 to the present date would encumber these pages with a mass of detail that might confuse the thought and take from the object in view. I will therefore give as short an account as possible of the different causes which have led to the perfection now attained in the application of iron to men-of-war, and then divide the armor-clads of all nations into five systems, showing the results attained in each.

Between the years 1855 and 1879 extraordinary activity has been displayed in naval science and maritime art. As early as 1859 Thorneycroft endeavored to do away with rivets and bolts by making tongued and grooved bars; and Russia experimented against steel plates four inches thick, with sixty-eight pound shot. The inventive talent of the United States was animated by the breaking out of the civil war—Knight, in his mechanical dictionary, mentioning fourteen patents that were granted for armor during the first three years of the Rebellion. Wire, rubber, millboard, chain-cables, papier-maché, cotton, hay, and logs of wood were proposed; some of these were put to the tests of experiment, and even actual engagement, but none were received with favor, while all were considered as makeshifts.

Wrought iron now began to be handled in greater masses than had ever before been deemed practicable, tremendous hammers and rollers, making heavier and heavier plates, were constructed until in 1867 the Atlas works succeeded, by means of Sir John Brown's carbonizing process, in producing a solid mass of iron fifteen inches thick, twenty feet long, and four feet wide. Bessemer, Siemen, Martin, and Whitworth manufactured steel, by new methods, nearly as cheap as iron. Krupp showed how breech-loaders would reduce the size of turrets,

and Armstrong replied that hydraulic machinery would accomplish a like result for his muzzle-loading guns. Naval architects lessened the weight of ships by novel systems of framing and made double hulls to resist rocks and torpedoes. In 1861 Coles was at work on his shields and Eads on his fixed turrets. During 1868–9 Elder wrote lectures upon his circular batteries, and Hyde discussed his scheme for double-deflecting armor, while three years before Austria had given Italy and the world a lesson at Lissa on the value of the ram and end-on attack. In July 1872, the English, lacking a foreign foe, cannonaded the Glatton's turret with the Hotspur's 25 ton gun. Soon after this date experiments were made as to the relative merits of iron and steel for armor, from which two facts were unexpectedly evolved; one, that a steel plate, of given thickness, might keep a certain projectile from piercing it even though the shot shattered the plate; whereas, when covered with wrought iron, the shot penetrated both iron and steel. The other, that a shot might pierce a plate of given thickness, but would fail to penetrate two of half that thickness, separated by an air space. In 1873 the German government submitted the Grüson dome-shaped turrets to severe tests; these turrets were made of iron cast in chill-molds, and united to one another by tongues and grooves. In 1876, the Spezia trials of the 100-ton gun proved the fallacy of many preconceived ideas concerning the value of steel and iron targets, and, besides inciting Sir John Brown to make a twenty-six inch plate, again brought out the inexhaustible powers of English foundries in the Wilson compound plates, (Fig. 1. Plate IV.) and the Whitworth combination of soft and hard steel.

Coincident with the changes and improvements in armor, during the past twenty-four years, is the growth of the gun and its projectile. We left the weight of shot in 1855 less than one hundred pounds, we find it, in 1879, increased to over two thousand. The power of resistance has only followed the means of offense. Above all the secondary reasons mentioned stands out, therefore, the one great cause which has produced the floating citadels of to day—the continued rivalry between artillery and armor.

We will now consider the various types of armor-clads. Although many vessels may be a combination of two or more of the following systems, we can in general classify the armored fleets of the world under five heads.

I. The Vertical or Broadside System.

II. The Turret System.

III. The Deflecting System.

IV. The Circular System.

V. The Ram System.

I. The Vertical System. The principle involved in this method of applying armor is the oldest of all, being the one naturally suggested to the human mind centuries ago. A shot is to be resisted, therefore increase the effectiveness of the bulwark, by adding to its thickness, or placing upon the ship's side a better defensive medium. This system also permitted the old type of vessel to be utilized, and new ones of similar proportions to be built; thus economizing the material already on hand, and catering to the proverbial conservatism of governments.

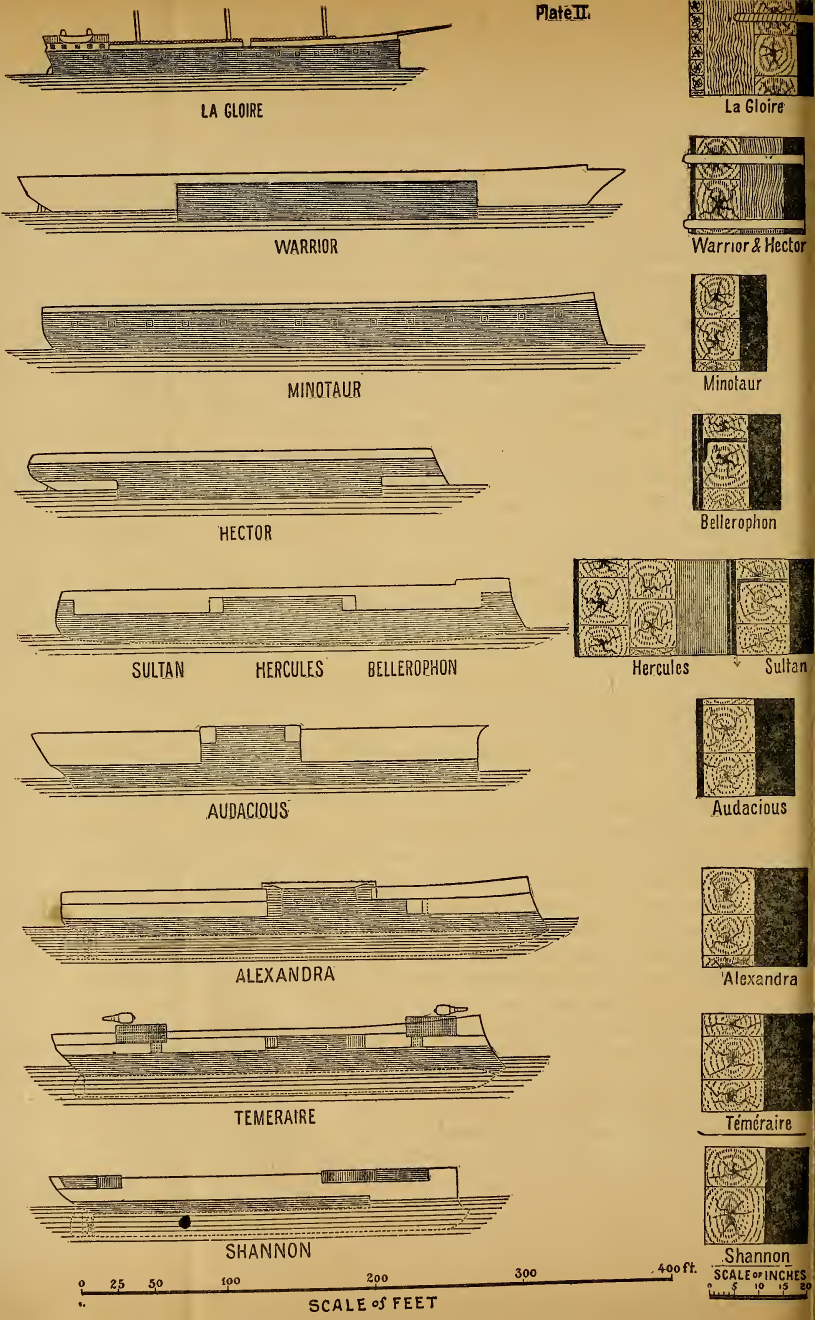
The vertical system is identical with the broadside. That it has been extremely tenacious of life may be seen by the perfection to which it has been carried abroad. America has never appreciated its merits. Our first iron-clad was a turret ship, and seeing that the monitors were superior to any corresponding type of other navies, we clung to that system, taught by the experience of former years that "in the one superior class" was our strength.

The only vertically armored broadside ship ever built in the United States was the New Ironsides, completed at Philadelphia in 1862. She was two hundred and forty feet long and had fifty-eight feet beam. Her armor was composed of four and one-half inch solid plates. She carried sixteen XI-inch guns and two 200-pdrs. She was burned at Philadelphia in 1865.

Returning to foreign dock yards, we find France, in 1858, already at work on a broadside iron-clad. The keel of La Gloire is laid, and England follows with the Warrior; vessels of widely different types, but both covered with four and one-half inch plates. The Warrior, on account of her extreme length, was only partially armored, while La Gloire was completely protected. The Warrior's iron hull was a step in advance of La Gloire's wooden frame, but the French frigate had the handiness of a shorter ship, the smooth sides, peculiar bow, and reduced canvas essential to the requirements of the times. That the English recognized the French model as correct in the main is shown by the Prince Consort, a vessel very similar to La Gloire begun three years after.*

* It is well to note here that La Gloire, Warrior, and Monitor were all launched in the same year. These three ships were, in embryo, types of the different systems to be developed in the next twenty-five years.

Plate II.


LA GLOIRE
WARRIOR
MINOTAUR
HECTOR
SULTAN
HERCULES
BELLEROPHON
AUDACIOUS
ALEXANDRA
TEMERAIRE
SHANNON
0 25 50 100 200 300 400 ft.
SCALE of FEET
La Gloire
Warrior & Hector
Minotaur
Bellerophon
Hercules
Sultan
Audacious
Alexandra
Téméraire
Shannon
SCALE of INCHES
0 5 10 15 20

Before 1863 the keels of several vessels four hundred feet in length had been laid, but this class proved unwieldy though possessing sufficient flotation to be completely armored. Then came the era of short ships, and, the destructive effect of ordnance increasing, buoyancy had to be given by additional beam; all-round fire next became essential, and decks and encumbrances were removed, wherever they interfered with the guns. Still the plates grew thicker, and lest the armor should become too heavy to be floated, all the parts above water were left free to be shot away, except those necessary for the battery, the guns being placed in a central casemate, where they could be fired in single or double tiers. It will be seen by the foregoing remarks that I refer to the series of iron-clads, which, beginning with the Warrior, includes the Minataur, Hector, Bellerophon, Hercules, Sultan, Audacious, and ends with the Alexandra—a vessel of such completeness that it is safe to say she is the perfection of the system of which we are treating.

France having expended large sums in her short sighted policy of repeating vessels of each class, and crippled by her war with Germany, has lost the prestige gained by her original departure from preconceived ideas of naval construction, but the Republic is observing critically, imitating successfully, the Dévastation—carrying a heavier broadside than any armor-clad afloat—being the latest result. England has ranged far ahead of her rival, both in novelty of design and form of hull, and the contrast between the navies of the two countries would be especially noticeable to one who might have the opportunity to see their fleets anchored side by side. The French frigates are covered with projecting surfaces, davits, cat heads, and bumpkins, while the smooth rounded sides of Her Majesty's ships are free from all encumbrances.

Germany, while deserving all praise for the energetic and practical manner in which she has increased her navy, gives us no new type, of armor-clad, her vessels having been built in England and France, or from plans borrowed from those countries.

It is scarcely necessary to allude to the other Powers, as they have presented no new varieties of the broadside system; though an exception may be made in favor of Austria, the armor of her casemated Tegethoff and Custozza being attached so as to lessen the weakness caused to heavy plates by extreme curvature.

The Alexandra [Plate II,] therefore remains the exponent of the best class of a vertical sided armor-clad. King gives the following

particulars concerning her:—"This vessel, the largest masted iron-clad heretofore designed, is a central-battery ship in the best sense—that is, she needs no bow nor stern batteries to give her end-on fire. For the first time a broadside armored masted ship is built with satisfactory all-round fire, for, out of twelve guns, four of them, including the heaviest, can fire straight ahead and two straight astern. On each broadside from four to six guns can be fought according to the bearing of the enemy. In other words, she has almost as perfect an all-round fire as is attainable in a broadside armored vessel, and this forms her chief claim to consideration. So far as the fighting portion of the vessel is concerned, she is a two-decker. The battery consists of two Woolwich rifled muzzle-loading guns of twenty-five tons each, and ten of the same kind but of eighteen tons each, the former being a size not previously attempted to be carried on a broadside-ship. The two 25-ton guns are located in the upper battery forward. These can be trained from 2° or 3° across the fore-and-aft line forward to several degrees abaft the beam. Two 18-ton guns have much the same training aft that the others possess forward. These four guns comprise the armament of the upper battery. To localize the effects of shells exploding between decks, the main-deck battery is divided by an armored bulkhead which forms a continuation downward of the forward bulkhead of the upper battery. In the portion which lies under, and corresponds with the upper battery, are six 18-ton guns, three on each side, for broadside fire only. In the forward and detached portion of the main battery are two other 18-ton guns for end-on fire, which they attain by means analogous to those employed to give similar fire to the upper-battery guns. Forward of the main-deck battery the whole side of the ship is set back from the level of the main deck (at the top of the armor-belt) upward. In other words, the ship forward of the battery is narrower above the main deck than below it; Four guns can therefore fire right ahead past the sides. Their arc of training is nearly 100°. The sills of the main-deck ports are nine feet, and those of the upper deck ports more than seventeen feet above the water. The water-line is protected by a belt having a maximum thickness of twelve inches and the armor forward is carried down over the ram, both to strengthen the latter and to guard the vital parts of the ship from injury by a raking fire from ahead, at times when waves or pitching action might expose the bow. The machinery, magazines, et cetera, are similarly protected against a raking fire from aft by an armor bulkhead, five inches thick. The

batteries are protected by armor only eight inches thick below and six inches above, which is a deficiency of protection against guns now in use on board armed vessels in European navies."

THE TURRET SYSTEM. This system of applying armor is not, as its name would imply, simply the mounting of a turret upon the deck of a vessel, as a shield for the battery and gunners. It includes concentration of guns in a small space, thereby bringing them more completely under control, enabling fire to be delivered in all directions, and affording the best defensive covering. We thus gain a few large guns instead of numerous small ones, and with a given flotation required for the ship can transfer the armor, which would otherwise be needed for the broadside, to the water-line.

A turret vessel may therefore be defined as an armor-clad of low free board, carrying a few large calibre guns capable of all-round fire from a revolving, armored turret.

The Monitor was such a vessel, presenting all the characteristics mentioned above, while the turret ships proposed by Eads and Coles were not; Eads' "armor clad central battery" having a fixed turret, and Coles' "cupola ship" lacking the feature of concentration so essential for the fulfilment of the theory.

The success of the turret system at Newport News led to the building of a great number of monitors, and before the close of the Rebellion the United States possessed a fleet of fifty-four vessels of this class; the most powerful being the Dictator, and all capable of defending our harbors against any foreign foe. Many minor defects in the original had been removed; but a few faulty details were allowed to remain, to which I would call attention as they seem likely to be perpetuated in the new monitors now building upon the Delaware. The means of egress from the hull is mainly from hatchways that can never be used in a seaway. By the addition of a low breastwork around the turret, extending to the port sills, the liability to jam the revolving gear would be lessened, and the crew, in any sudden emergency, would have an additional means of escape at sea from hatchways within the breastwork. These hatchways could also be kept open in moderate weather to admit light and air. The arrangement of the deck steering gear is also bad and the manner of loading, both antiquated and slow.

Although England placed little confidence in the turret system at first, a mongrel vessel, combining the advantage of low freeboard and the disadvantages of lofty masts and heavy top hamper, was constructed after plans suggested by Captain Coles. She was christened

the Captain, armored with from six to ten-inch plates, and capsized on her trial trip September 6th, 1870.

The Monarch was a more successful vessel; but the advantage obtained by her revolving turrets is partially counter-balanced by the retention of masts, and the freeboard of fourteen feet presented to the fire of an enemy. Neither of these ships therefore fulfil all the requirements of the turret system.

In 1864 the English cut down the Royal Sovereign, covered her with five and one-half inch plates, and placed four turrets, containing four nine-inch guns, upon the former three decker. The Scorpion, with two turrets was also launched about this time; but it was not until after the Miantonomoh's voyage to Europe that the coast defense monitors were begun, and Ericsson's type imitated, to be in many instances developed into a better vessel. Solid plates immediately took the place of laminated, the glacis and breastwork were added, the thickness of armor was gradually increased to twenty-four inches, iron hulls were substituted for wooden, wood backing was used in the turrets, behind which came an inner skin and a mantlet to protect the gunners from flying rivets and bolts. The decks were armored horizontally and a ram-bow in many cases added.

It would carry this paper far beyond its limits to refer to the peculiarities of each class, or, properly speaking, of each vessel, but the distinctive features of the twenty odd turret vessels of the English navy may be easily obtained from the standard authorities. If the sequence be followed from the Cerberus (built for colonial defense in 1868) through the Fury (1870), Glatton (1870), Gorgon (1871), Devastation (1871), Dreadnought (1877) to the Inflexible (1879) it would be seen how far these ships have departed from the original model; though maintaining, under the ever changing relations between offense and defense, the cardinal points of the turret system.

We have noted, when treating of the vertical system, how the increase in the weight of armor has gradually stripped it from the high sides of the frigate until casemate and water line alone were protected; now, although turrets by their reduced size and rounded exterior, give a less weight of armor than the casemate, the limit of buoyancy has been reached even with them; and we find in the Inflexible, an armor-clad so widely differing from Ericsson's Monitor that the "citadel ship" may be said to represent an entirely novel system. Mr. Barnaby, her designer, gives us the following description:—

"Imagine a floating castle one hundred and ten feet long and seventy-

five feet wide, rising ten feet out of water, and having above that again two round turrets, planted diagonally at its opposite corners. Imagine this castle and its turrets to be heavily plated with armor, and that each turret has two guns of about eighty tons each. Conceive these guns to be capable of firing, all four together, at an enemy ahead, astern, or on either beam, and in pairs toward every point of the compass. Attached to this rectangular armored castle, but completely submerged, every part being six to seven feet under water, there is a hull of ordinary form with a powerful ram bow, with twin screws and a submerged rudder and helm. This compound structure is the fighting part of the ship. Seaworthiness, speed and shapeliness would be wanting in such a structure if it had no addition to it; there is therefore an unarmored structure lying above the submerged ship and connected with it, both before and aft the armored castle, and as this structure rises twenty feet out of water from stem to stern without depriving the guns of that command of the horizon already described, and as it moreover renders a flying deck unnecessary, it gets over the objections which have been raised against the low free board and other features in the Devastation, Thunderer and Dreadnought. These structures furnish also most luxurious accommodations for officers and seamen. The step in advance has therefore been from fourteen inches of armor to twenty-four inches; from thirty-five ton guns to eighty tons; from two guns ahead to four guns ahead; and from a height of ten feet for working the anchors to twenty feet. And this is done without an increase in cost, and with a reduction of nearly three feet in draught of water."

Italy has gone a step further in the construction of floating castles, and intends to defy the world with her diagonally turreted Duilio and Dandolo, plated with solid steel armor, twenty-two inches thick. Even with these monsters she is not content, but lays the keels of the Italia and Lepanto, stupendous floating batteries four hundred feet long, with oval, armored redoubts to enclose turrets of some extraordinary thickness, to be determined by future experiment.

Rumors are already bruited about that the Duilio will not float her heavy armor, and until the Italia and Lepanto are launched we must hold with the British director of naval construction that, in the Inflexible, we have reached the extreme limit in thickness of armor for sea going vessels.

The other Continental Powers have been imitators of the American and English turret ships. Russia has a Devastation in her Peter-

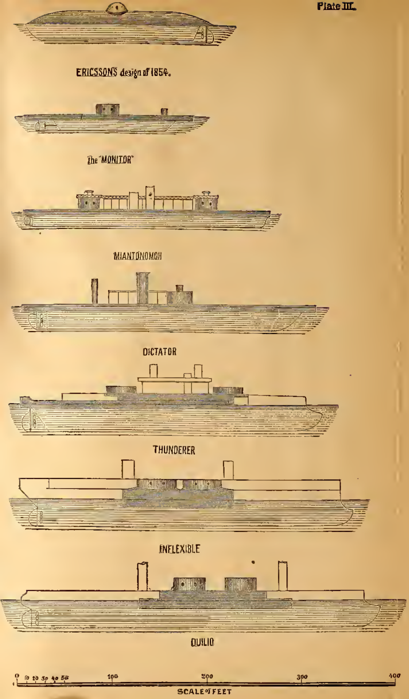
The-Great, Germany, a Monarch in the Preussen, Austria, monitors in the Maros and Leitha, France has steadily set her face against the system, her whole navy list containing the names of only two turret vessels in actual service—the Unandaga and the Cerbere.

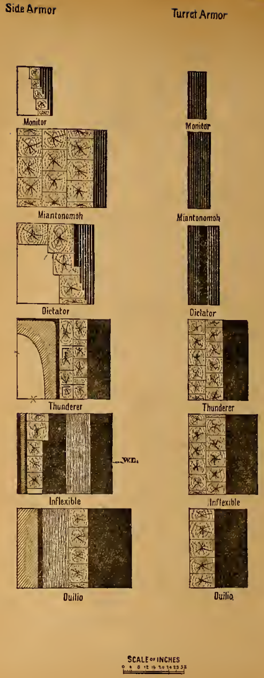
III. THE DEFLECTING SYSTEM. The plan of lessening the chance of penetration, by placing the armor at an angle to the vertical, was both originated and developed in this country. Gregg and Stevens proposed deflecting armor in the earlier part of the century, Tees and Caudwell made complete models of iron clads with inclined sides nearly twenty years ago; while the first vessels built on this principle were used on both sides during the Rebellion. The Merrimac was an example of the type, and the gun-boats of the De Kalb class embodied the same idea. Before the close of our war there were numerous craft of this description afloat on our western rivers, with plating varying from four inches to three-fourths of an inch. Even the latter, though termed ironically "tin clads", did excellent service. The most powerful vessel of this description was the Dunderberg, built by Webb—her solid plates varied from four and one half to three and one-half inches in thickness. She was sold to France and re-named the Rochambeau.

Hotchkiss, about 1862, invented an ingenious method of attaching over-lapping plates, after the manner of shingles. The efficiency of the inclined side was thereby increased, and a shot finally thrown back into the water. An English engineer, named Hyde, elaborated the system spoken of before the United Service Institution in 1869. His armor was to be attached to a hull of such shape that a shot striking either above or below water would be received at a very acute angle. The arguments used in favor of this double deflecting system were the great resistance offered to penetration, the protection afforded in a sea way, and that the lines of a vessel to which such plates had to be attached would give more stability than those of a ship with vertical sides. Captain Palmer of H. M. S. Magdala has also proved that inclined armor is two and one-fourth times as effective as vertical of the same weight.

Of late years the deflecting system is again receiving its share of attention, the Engineer remarking, in 1876, that, "since the Spezia experiments, there are but two possible chances for the plate, and these will be found in so disposing it that the shot may strike it at an angle, and in using air spaces." Combined with the deflecting surfaces presented by turrets this system may therefore become one of importance;

Plate III.


ERICSSON'S design of 1854.
The "MONITOR"
MIANTONOMOH
DICTATOR
THUNDERER
INFLEXIBLE
DUILIO
0 10 20 30 40 50 100 200 300 400
SCALE OF FEET


Side Armor
Turret Armor
Monitor
Monitor
Miantonomoh
Miantonomoh
Dictator
Dictator
Thunderer
Thunderer
W.L.
Inflexible
Inflexible
Duilio
Duilio
SCALE OF INCHES

and we may in the future see improved Merrimacs and Tennessees as we have already witnessed perfected Monitors and Warriors.

IV. The Circular System. The advantage of this system lies in the immense flotative power given by the shape of the hull, and the consequent ability to carry heavy armor. The merit of having proposed a circular iron-clad is due to Elder, an Englishman, who, in 1868, described the system in all its details, giving plans of a vessel which, in essentials, was identical with the later Russian Popoffkas. "There may,"—as Mr. Reed said in his lecture before the United Service Institution, "be old books that contain engravings showing such a ship filled with armed men;" but neither Mr. Reed nor any one else has ever been able to name those books. Admiral Popoff may be credited—as the lecturer further infers—with being the man to call circular iron-clads into existence, but it is the credit that should be given to one who, through unlimited means and power, has been able to give practical effect to the inventor's theoretical proposals. The first of these vessels was launched at Nicolaief, southern Russia, in the spring of 1873. She was called the Novgorod, and was followed by the Admiral Popoff. These ships are alike in principle, the Admiral Popoff having an extreme diameter twenty-one feet greater than the Novgorod. The latter is completely circular at the water line, with the exception of a small protuberance at the stern for the steering apparatus; the bottom is flat and has twelve keels attached to it parallel to one another, and at equal distances apart. The diameter is 101 feet just above water, and 76 at the flat bottom. The deck slopes from a central height of five feet to less than two at the circumference. Coinciding with the centre is a fixed tower carrying two eleven-inch B. L. guns. The top of the tower is only seven feet above the deck. The displacement of the ship is 2491 tons. The armor consists of two layers, an inner one, of unusual form, consisting of corrugated iron beams seven inches deep and one and a half inches thick, connected to the skin of the ship. The outer plates are in two tiers, the upper nine inches, and the lower seven inches thick. The turret armor is nine inches, backed with teak of same thickness; within this is an iron skin. Two feet of timber cover the armor at the water line. The bottom is double, and the hull divided into thirty-six compartments. The dimensions of the Admiral Popoff are proportionally greater, and she was the first vessel ever floated with plates equivalent to eighteen inches.

I have gone into more particulars concerning these vessels than their

merits seem to justify, from the fact that at the time of their launch great importance was attached to the event—the ex-chief constructor of the royal navy deeming the Popoffkas worthy to be compared with England's iron-clads. The low speed obtained by the circular ships, their complicated machinery for driving the six propellers, the large horizontal target they present to an enemy, and their low towers —from which the guns are to be fired, en barbette—are all radical defects in the system, which prevent it from ever assuming an important position in naval warfare.

The Popoffkas were never heard from during the late Eastern war, though constructed with a special view to operations on the Black Sea; and it is an open question whether the "turret citadels," for harbor defense, proposed by Timby, many years ago, and which could have been towed from port to port faster than the Novgorod can steam, were not better adapted for coast defense.

V. The Ram System. The history of rams begins long before the Christian era. The Persians taught the Greeks how to use the ram at Salamis and Actium, and, 480 B. C., Queen Artemesia initiated the practice of running down a friendly vessel, but with a more laudable object than has been lately done by modern armor-clads. Then, as now, the ram successively changed its form from the overhanging to the straight, and the under water projection, and tactics were modified to suit the alterations in the type of vessel. It is beyond my province, however, to treat of this subject, which belongs more to the development of ships than to the application of armor; for plates may be fastened to a ship fitted with a ram-bow in the same way that they are to other vessels.

James Nasmyth advocated the steam ram as long ago as 1836, and almost all modern ironclads have been supplied with this means of offense. No modern vessel, it must be admitted, presents the proper qualifications, and when we come to the discussion of the ram of the future the question offers features which materially modify the present methods of applying armor. The true ram must present the minimum amount of surface to horizontal and plunging fire; need have no offensive armament save her snout and torpedoes; and no defensive guns except such as are necessary to free her deck from boarders. The thickness of her armor can therefore be greater than that for any other type of vessel. Such a craft was suggested by the cigar shaped boats of our war, and has resulted, in England, in the Sartorius Ram. In this vessel convex steel plates, fastened in a nov-

el manner to the small portion of the hull above water, are to be united to a steel frame armored with heavy plates. In this country, the ram has been carried to a great degree of perfection by Admiral Ammen, but the lack of appropriations has prevented his plan from being supplemented by an actual vessel, and England will undoubtedly have the first genuine ram afloat, though its design will embody features long since advocated by the ex-chief of our Bureau of Navigation.

Several methods of fitting armor have come into use, that do not strictly belong to any of the foregoing systems.

I. The Barbette System, so persistently used by the French. It includes the plan of a fixed tower, over which the guns fire. The arguments used in favor of this system are that the tower being lower than the revolving turret its weight is diminished; that an enemy can be clearly seen; and that the morale of the gunners is better assured than in an enclosed battery.

II. A combination of barbettes and rounded projecting casemates. Several vessels of the French navy are constructed on this principle, the towers being placed near the ship's side.

III. A system similar to the above, except that the towers are placed at bow and stern, a casemate containing two tiers of guns being added amidships. The English Téméraire (Plate II.) is an armor-clad of this description.

IV. The Belt System. The English authorities, frankly acknowledging the impossibility of protecting both guns and hull, have, in the Shannon, (Plate II.), abandoned battery armor, and limited the plates to a belt nine inches thick, extending from a vertical armored bulkhead at the stern to a similar one sixty feet from the bow. These bulkheads are a protection from fore and aft fire, and the crew are to run the chance of being struck by shells delivered above the belt; the alternative being that they would probably be wounded first and drowned afterward, if the weight of armor were distributed over a greater surface.

V. Torpedo Vessels. The armor for torpedo boats has thus far been a simple mantlet to protect their crews from small arms and gatlings. The revolving guns of heavier calibre, now coming into use, may necessitate a thicker plating, but this class of vessel must always depend upon celerity of movement rather than upon shot proof covering.

The analogy between the history of personal and ship-armor has forcibly presented itself to my mind while writing the preceding pages. If we follow the comparison through its various steps it will be noticed that the knight of the earlier centuries was clad in all sufficient plate, even as the first iron-clad was encased in complete armor; plate and armor growing thicker and heavier as projectiles became more powerful. In both cases, the limit of weight being reached, recourse was had to deflecting systems, subsequently rendered less vulnerable by padded coat or wooden backing. In our own century the helmet of the dragoon and the cuirass of the guards still lingered, furnishing prototypes of the Inflexible class, the vital points alone protected. Before the deadly weapons of the past decade the soldier throws aside all defensive covering and becomes the light mobile skirmisher of recent wars. Whether we are to follow the sequence to such a finality is a question which, though logically correct, is still open to dispute.

That the days of armor-clads built on the vertical system are numbered most of us will admit, the latest argument against them being that every point of the target, presented by their high freeboard, becomes a *fuze*. In other words the heat developed by a large calibre rifle shell passing through armor-plate is sufficient to explode it within the ship, among a crew pent up in a contracted casemate. Were the same projectile to strike a wooden vessel it would pass completely through her, bursting beyond and leaving a hole possible to plug.

Like arguments may undoubtedly be used to the disadvantage of the turret system, but the monitors present such a small surface, that it is still questionable whether recent monster guns, though possessing sufficient power to pierce any plate, can be practically worked against them.

The destructive effect of the ram has been so thoroughly proved, its power to carry heavy plates so completely demonstrated, that armor will be carried on this class of vessel long after it is stripped from other ships.

Rams built after the design proposed by Admiral Ammen* would cost comparatively little, and one in each of our harbors, supported by monitors and torpedo boats, might successfully resist the largest ironclads.

We are next to decide upon the kind of armor necessary for our

* For a description of the Ammen Ram see page 175 of this volume.

FIG I

FIG 2

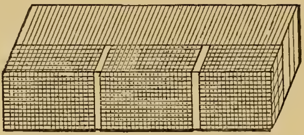
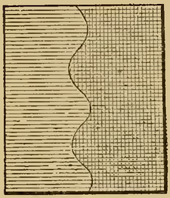


FIG. 3



STEEL

IRON

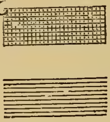
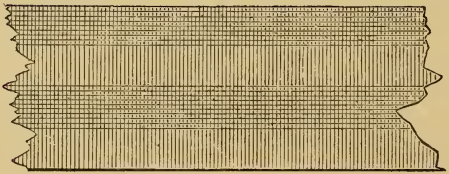


FIG 4



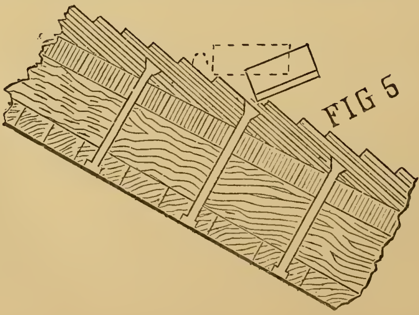


FIG 5

rams and monitors. The experiments in Germany with the Grüson dome shaped castings, chilled on the outside and slowly cooled on the interior, have proved that cast iron may be made into a much better plate than has heretofore been deemed practicable. Still I am inclined to believe that cast iron will never be strong enough for the purpose, and that its lack of malleability will prevent it from ever being used for the curved surfaces of a ship's side.

Wrought iron possesses many requisites upon which it is not necessary to dwell, but the very advantages which render it a desirable metal to work into shape and easy to fasten to the frame of a vessel make it penetrable by rifled projectiles.

Steel, while possessing many of the characteristics of wrought and cast-iron, has the additional quality of hardness, which gives it a great superiority over both for the purposes of which we are treating. Low steel, though not as hard as high, has much more tenacity, and would seem to be the variety necessary for our use. But steel, though hard enough to resist the blow of the largest calibre projectile, is liable, after being struck, to crack, become loose, and ultimately to detach itself from the backing. To remedy these defects, it has been proposed in England to make the body of the plates of wrought iron, and the exposed surface of steel. These plates (Fig. 1), called the Wilson compound armor, are made as follows;—"The wrought iron is introduced (horizontally) into a furnace of peculiar construction, and when it has arrived at a welding heat, the melted steel is run in on top of it. The damper is then closed, and the crown of the furnace removed, a chilling plate being put on top of the steel; or the refractory bed and sides containing the steel and wrought iron may be removed on a 'bogie' and cooled outside."

Whitworth proposes to make the body of the armor of very soft steel, and to plug it with the hard steel bolts—these bolts to receive the force of impact. The Italians are also making experiments with steel bricks twenty-two inches thick, set in wrought iron cells.

The results obtained from these various plates go to prove their great superiority over all others. Two points, developed by the tests applied to the Wilson compound armor, demand attention, viz.—that the union beween the steel and wrought iron was not injured, and that the outer casing of steel, though cracked by the large shot used against it, still held on to the backing. By way of making these plates still stronger it has been proposed to pour the melted steel over a corrugated wrought iron plate, (Fig. 3) thus making the junction

between the metals more firm. To localize the cracks the steel is to be separated by small intervals (Fig. 2) or the exterior of the plate is to be made of alternate layers of iron and steel. (Fig. 4.) These facts naturally lead us to the conclusion that the armor of the future will be a combination of steel and iron in some form.

Steel is now being made remarkably cheap in this country by the Bessemer, Siemen, and Pernot processes, and the want of heavy hammers and rolling mills can be neutralized by the decreased thickness of the wrought iron demanded for the compound plates.

In this connection I would suggest that the Hotchkiss Armor (Fig. 5) might be utilized. The projecting edges, instead of being put on in layers, to be fused to a wrought iron backing. Again a deflecting system, like the Hotchkiss, gives us ample room for a water or air space between a *double line of armor*, an advantage to which I have already alluded.

I find myself digressing, Mr. Chairman, into a field which is not covered by the title of the lecture, and will not further tax your patience with a recital of my views of the future man-of-war. The needs of the service in that direction will undoubtedly be thoroughly discussed in our next Prize Essay.

A word of explanation and I am done. The preceding pages were prepared to supply a want which I discovered while endeavoring to obtain a few details in regard to armor. The subject is scattered over so many works and periodicals that much time was lost in consulting numerous volumes which contained little or no information. In order to aid the student I have endeavored to condense the main features of the History of Armor, and by way of further assistance, in the same direction, will add at the end of this lecture a list of the standard authorities from which my notes have been taken.

1. Engineering—Vols. 4, 5, 6, 7, 9, 12, 13, 14, 15, 17, 18, 19, 21, 27.
2. Engineer—Vols. 32, 33, 35, 36, 40, 41, 42, 43, 44, 45.
3. Holley—Ordnance and Armor.
4. Spon's—Dictionary of Engineering.
5. Knight's American Mechanical Dictionary.
6. Journal Royal U. S. Institution—Vols. 2, 4, 6, 7, 8, 11, 12, 16, 17.
7. King—Report on European Ships of War.
8. Report of Secretary of the Navy 1864.
9. Scribner's Magazine, April 1879.
10. Haydn's Dictionary of Dates.

11. Johnson's cyclopædia, art. ships, iron-clads.
12. Elgar's, Ships of the Royal Navy.
13. Ericsson's, Contributions to the centennial exhibition.
14. Appleton's Am. annual cyclopædia 1864, p. 720.
15. Dahlgren's Report of the Kinburn engagement.
16. Armor Plating etc., Major King, 1870.
17. The Steven's Battery—Memorial to Congress, 1862.

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Lieut. Brown. In regard to what Lieut. Miller states about rams I would remark that there is little difference between the Alarm and the ram suggested by Admiral Ammen. They were both designed for this purpose by distinguished officers, and were modeled, I think, by the same constructor.

The Alarm is designed to strike ten feet below the water, whereas the ram proposed by Admiral Ammen is to strike but two feet below the surface. Owing to the plan of carrying armor so far below water which now seems to be coming into favor, I think ten feet the better. A ram running well ahead affords stability for armor and guns on the bows. Numerous water-tight bulkheads with doors self closing when the compartment commences to fill, would prevent the ship from sinking forward when the ram was injured.

The ram proposed by Admiral Ammen is to be a turtle back with armor three inches thick. I think with armor on bows as on Alarm the same invulnerability can be obtained. Of course it will be necessary to fight the vessel having armor like the Alarm bows-on but that is the natural way to fight a ram. The Ammen ram has two screws to drive her thirteen knots. The Alarm has not yet equalled that speed but it is undoubtedly a fact that vessels of her model can be driven that fast.

The general plan of hull of these vessels is the same—both built on the transverse bracket system with two skins and heavy longitudinal frames. The ram is two hundred and five feet long, thirty feet wide and thirteen feet draft, while the Alarm is one hundred and seventy-three feet long twenty-seven feet wide and ten feet draft. The skeg of the Mallory propeller will, however, increase her draft. The blow delivered by either would be ample to destroy any ironclad. I can see no advantage in building vessels as large as the proposed ram and having no bow gun on them.

Lieut. Stockton. It has seemed to me that Lieut. Miller in giving the entire preference to the turret system, has only considered one side of the case in relation to the broadside system, and that is the defensive. It appears to me that when the vessel is acting on the aggressive, the broadside vessel has advantages over the turret ironclad; more particularly while attacking shore batteries and forts. I would like to hear from those officers who witnessed the New Ironsides and monitors attack the shore fortifications before Charleston. I know of no recent engagement where a combined force of broadside and turret vessels made an attack on works on shore.

Commander Cotton. It was a noticeable fact, in the various attacks of the ironclad squadron upon the earth and sand works before Charleston, that the New Ironsides, with her broadside, which was composed of seven XI in. guns and one 200 Parrott rifle, could silence the fire of batteries Wagner and Gregg with comparative ease; whereas, when these works were engaged by several monitors, whose united number of guns equalled

or exceeded, and whose weight of metal exceeded the broadside of the Ironsides, the batteries were not only not silenced, but they briskly returned the fire of the monitors.

Civil Engineer PRINDLE. I was attached to one of our gun-boats during the operations before Charleston, alluded to by Commander Cotton, and can fully corroborate his statement. I often saw the whole monitor fleet engage those batteries for several hours at a time, and often supplemented by the gun-boats, having larger Parrott rifles, at long range, with the enemy returning gun for gun through the entire action. The monitors would then be withdrawn and the New Ironsides, with her broadside battery, go into action and speedily silence the enemy's fire alone.

Lieut. STOCKTON. Although experience shows to a certain extent that a broadside iron-clad cannot be entirely armored, still if the ship floats she can be of the greatest service, and perform certain work that a turret vessel cannot; hence I think a belt line of armor at the water line will keep her afloat and in a state of high efficiency. Not that I consider a broadside iron-clad the typical vessel, but that she can accomplish certain highly important work better than any other class extant.

Lieut. MILLER. In the space at my disposal it was impossible for me to go deeply into the subject of torpedo vessels, and whether rightly or wrongly the Alarm has always been classed under that head. She undoubtedly has a ram, but she also has a gun and torpedoes, and these two additional modes of offense seem to me to destroy her distinctive feature as a ram. Lieutenant Brown has lately given us a very able and complete description of the vessel he commands. I trust he will shortly supplement it by an account of how he would fight her against an iron-clad. How is he always to keep bows on? When fire his gun? When ignite his torpedoes? It will take a cool head to decide three such vital points at a moment when one's whole force should be concentrated upon striking the enemy at a given point. The forty-five thousand pounds of the XV inch gun and carriage would I think be much more advantageously disposed as armor for her exposed parts, while in the crash of contact with the enemy the torpedoes are as liable to inflict injury on the ram as on the rammed.

In regard to the remarks of Lieut. Stockton, Comd'r Cotton, and Civil Engineer Prindle, I naturally hesitate to oppose the views of officers who have seen the relative merits of the broadside and turret systems tried in actual engagement. But I think the test presented by the operations before Charleston scarcely a fair one. It must be remembered that the monitors were then novel craft, their mechanism new to the service and their method of loading and firing developed only in the crudest manner. In the future turret ship we may hope to see, among other means of promoting rapidity of fire, hydraulic loading gear, and a hollow, central shaft for hoisting projectiles for breech loaders. No time will then be wasted in revolving the turret until the "shell whip shall be fair with the hatch." If, during a given time, we can throw the same amount of metal into a fort from a turret ship as we can from a broadside vessel, we will do the same amount of damage, and will ourselves receive less injury in return in our small target. I quite agree with Lieut. Stockton that an iron-clad armored on the Belt system is a most useful class of vessel, and the service would be fortunate indeed did it possess many of them. My object in the concluding remarks was simply to show the type of ship most necessary for the navy at the present date to repel the attacks of foreign fleets.

Lieut. RUSH. I should like to ask the lecturer if the Wilson plates he describes have ever been fitted to vessels. Mr. Miller also speaks of the use of air spaces. I would also enquire the extent of the experiments carried on in regard to distributing armor in two layers with an intervening water or air space.

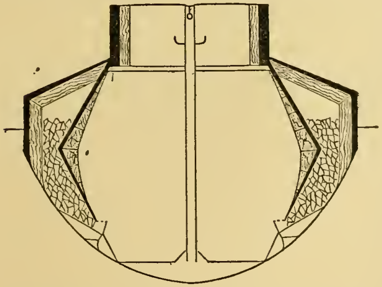
Lieut. MILLER. I see by the late papers that the Ajax and Agamemnon, two vessels of the Inflexible type, but of smaller dimensions, are to be fitted with compound armor; but, as no details of the plates have as yet

reached this country, I cannot state whether the Wilson combination of steel and iron is to be used or not.

The only experiments to test the value of air spaces were made in England about three years ago. The thirty-eight ton gun fired an eight hundred pound shot completely through nineteen and one-half inches of iron, and ten inches of teak, at seventy yards range. The gun was next fired against a ten inch plate, and a four inch plate backed with thirteen inches of teak, a space of six feet being left between the two. When this second target was examined, after the experiment, it was found that the shot had passed through the ten inch plate, and had been broken to pieces, against the four inch plate without injuring the latter in the least degree.

The apparent anomaly presented by the above experiment may be explained as follows; a shot strikes a thick plate and, like the tallow candle fired at a pine board, it finds its way through the iron; but during its passage it has developed in it so great an amount of heat that the metal of which it is composed is upset. The crystalline structure of the projectile is destroyed, but the surrounding plate, holding it in a vice, prevents the particles from separating. As soon, however, as the shot is released and passes into the air space, the least shock will shatter it.

I had not intended, Mr. Chairman, to present any novel method of construction, as air spaces and compound armor have not been sufficiently tested as yet to warrant their adoption; but the discussion having led towards the subject, it will not perhaps be out of place to show the manner in which the future turret ship may be armored.



The figure on the board is a rough sketch of a proposed sea going monitor. The outer plating ten inches thick, the inner four inches, with an interval of six feet between the two—Wilson armor to be used. The inner layer you will notice is carried, say four feet, below the water line before it slopes towards the keel. My idea in doing this is to deflect shot which may strike below the water line. The space between the two layers of armor is to be used as a coal-bunker, as experiments made during our war proved that coal was a great deflector, and tended to throw the projectile, upward or in the line in which it met the least resistance. It is scarcely possible that the coal would prevent a projectile, already upset while passing through the outer armor, from flying to pieces. The central spindle should be hollow and used for hoisting shot and shell. The base of the turret should be protected by the inclined armor.

Lieut. Brownson. Will Mr. Miller tell us why he makes his inner layer four inches thick, when, as he says, the projectile is already shattered after passing through the outer armor.

Passed-Ass't. Eng. Manning. I think Mr. Miller is slightly in error about the first iron-clad built in this country as it is my impression that the "Re d' Italia" built by Mr. Webb of New York about the year 1860 for the Italian government, was at least partially iron plated. She was sunk at the battle of Lissa in 1866 and is spoken of in the accounts of that fight as an iron-clad ram. Mr. Miller, in comparing the several systems, has omitted to mention the most vulnerable point of the monitor system—the deck—which has but little resistance to shot if struck at close quarters.

Had the Merrimac been able to depress her guns sufficiently in her memorable fight with the Monitor I fear there would have been a different ending. At long range there is very little danger, as the angle at which a shot could strike the deck would be so acute as to cause it to glance.

Lieut. Miller. The relative thickness of the two layers must of course be determined by future experiments. I used four inches simply to illustrate the system, that being the thickness of the English target to which I referred.

I am indebted to Mr. Manning for drawing attention to the vulnerability of the deck of the monitors. It is undoubtedly their weak point, but the use of inclined sides as shown in the drawing will obviate that defect, while the reduction of thickness of the new armor, will enable us to distribute it to better advantage. I have been unable to find any details regarding the Re d'Italia, but if I succeed in doing so will insert them as a note in the body of the lecture. Before the meeting adjourns I should like to express my thanks to Cadet Midshipmen Hunicke and Cramer for the excellent plates which accompany my lecture.

The Chairman. I have listened with extreme interest to the paper presented to us by Lieut. Miller, and I believe that I am expressing the feelings of all the members present in thanking Lieut. Miller for his very able paper.

# PROFESSIONAL NOTES.

These articles not having been read before the Institute are inserted by direction of the Executive Committee.

# CHEMICAL THEORY OF THE COMBUSTION OF GUNPOWDER.*

By R. Bunsen and L. Schischkoff.

Translated by Chas. E. Munroe, Prof. U. S. N. A.

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In spite of the apparent simplicity which the phenomena of the combustion of powder present, a combustion upon which the mechanical effect produced depends, we are far from knowing exactly all the circumstances which surround it. The researches of Gay Lussac, completed more than thirty years ago, are the first and the most complete which were undertaken upon this subject; more recent investigations have led to results so contradictory that it has been impossible, up to the present day, to devise a chemical theory which would agree with the experimental results.

Let us admit that practically the normal composition of powder corresponds to two molecules of saltpetre, one atom of sulphur and three atoms of carbon. If all the carbon is converted into carbon dioxide and all the nitrogen is set free we should have the following equation.

$$2\,KNO_3 + S + 3\,C = 3\,CO_2 + 2\,N + K_2S$$

Then one gram of powder containing

| | |
|---|---|
| Saltpetre | .7484 grms. |
| Sulphur | .1184 |
| Carbon | .1332 |
| | 1.0000 |

Will give after its explosion

| | | | |
|---|---|---|---|
| Potassic sulphide | 0.4078 grms. | | |
| Nitrogen | 0.1037 " | = | 82.52 $cm^3$ |
| Carbon dioxide | 0.4885 " | = | 248.40 " |
| | 1.0000 | | 330.92 " |

* This translation was made from the French of M. A. Terquem, the original paper not being then accessible. It has since been compared with the original memoir (Poggendorff's Annal. der Phy. u. Chem. CII, 321) and, while the form of the French translation is preserved, numerous errors in it have been corrected. The translator has also converted the old chemical notation and nomenclature into the new forms now in vogue with chemists.

The volume of the gases will remain constant even though carbon protoxide should be formed in the place of carbon dioxide and nitrous oxide in the place of free nitrogen. Now if we except some slight traces of hydrogen and hydric sulphide and if there are no other gases produced but carbon dioxide, carbon protoxide, nitrogen and nitrous oxide we can regard this volume of gas 330.92 $cm^3$ as being the maximum volume which can be formed by the combustion of one gram of powder having the normal composition. Gay Lussac and other more recent observers* have found volumes much greater than this. These contradictions show the imperfections of the methods used in their researches and have led us to return to the question while employing a more exact method of research.

We set out to determine

1. The composition of the solid residue from the combustion of the powder.
2. The pulverulent matters which form the smoke.
3. The substances composing the gas.
4. The relative quantities of solid residue and of smoke for a given weight of powder.
5. The quantity of heat developed and the temperature of the flame.
6. The pressure exerted by the gas, the explosion having taken place in the space occupied by the powder in the state of grains, and supposing that no heat is lost by radiation or conduction.
7. The theoretical work which the powder can produce.

On account of the limited amount of time which we could command for our common work we have not been able to determine these experimental data but for a single species of powder, and under the ordinary atmospheric pressure. Therefore we offer our work only as an application of the method which we have followed, a method which could, with some slight modifications, be applied to the study of the combustion of powder under other circumstances.

We have determined the composition of the powder which we have employed by treating it first with water, which gave us the weight of saltpetre; the insoluble residue was then treated with carbon disulphide which dissolved out the sulphur; and the new residue burned with cupric oxide yielded the quantities of carbon, hydrogen and oxygen which it contained. We have found in this way for this powder:

*Piobert, Traitè d'artilleire, p. 265

| | | | |
|---|---|---|---|
| | Saltpetre | 78.99 | per cent. |
| | Sulphur | 9.84 | |
| Charcoal | Carbon | 7.69 | |
| | Hydrogen | 0.41 | |
| | Oxygen | 3.07 | |
| | Ash | traces | |
| | | 100.00 | |

We have used our different apparatuses according as we have wished to determine qualitatively or quantitatively the nature of the products of the combustion.

## QUALITATIVE ANALYSIS.

For the qualitative analysis we have employed the following apparatus (Fig. 1, see plate.) We took a glass tube sufficiently large, closed at one end by a stopper (b) and carrying at the other end a tube for conducting off the gases. Through the stopper a small brass tube (a), 250 mm. long and 2 mm. in diameter, passes, in which the pulverized powder is put. The powder is ignited and when it begins to issue in a regular jet from the tube the stopper (b) is fitted into the large glass tube. The flame from the powder is liable to break the tube (d) on account of the high temperature which is developed in the part of the tube which surrounds the powder. In order to avoid this the tube (a) is enclosed quite to its extremity in a tube of perforated sheet iron or, what is quite as good, another tube of thin glass. The solid residue and the substance held in the pulverulent condition by the gas, under the form of smoke, remain in the tubes (a) and (d), the gases are received over a vessel of pure mercury after they have been allowed to pass freely until they have driven all of the air from the tube (d). The analysis showed that the solid residue was composed of

1. Potassic sulphate.
2. Potassic carbonate.
3. Potassic hyposulphite.
4. Potassic sulphide.
5. Potassic hydrate.
6. Potassic sulphocyanate.
7. Potassic nitrate.
8. Carbon or charcoal.
9. Sulphur.
10. Ammonic carbonate.

The gaseous products contain the following gases:

1. Nitrogen.
2. Carbon dioxide.
3. Carbon protoxide.
4. Hydrogen.
5. Hydric sulphide.
6. Notable quantities (according to circumstances) of nitric oxide and even of nitrous oxide.

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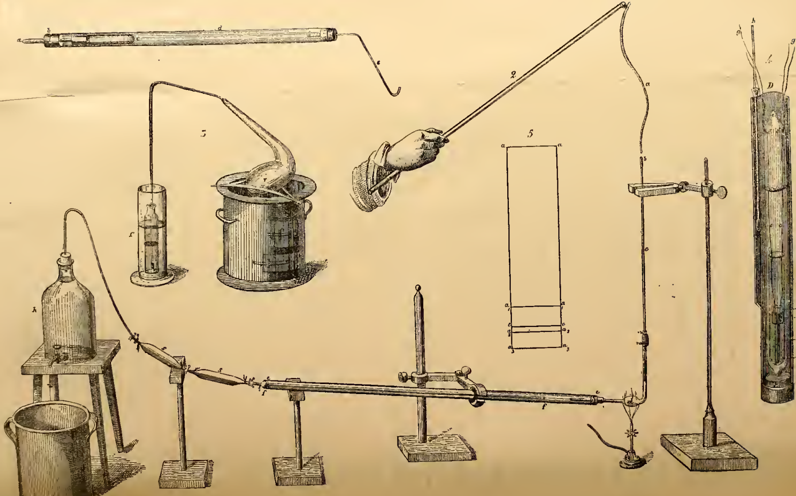

BUNSEN & SCHISCHKOFF.

CHEMICAL THEORY OF THE COMBUSTION OF GUNPOWDER.

## QUANTITATIVE ANALYSIS.

In order to obtain easily and without danger a considerable quantity of these bodies for quantitative examination we have employed the apparatus shown in Fig. 2. It is composed of a glass bulb (d), which is heated by the aid of a gas lamp, in which the combustion is effected and where the solid residue remains. To one of the bent extremities of this bulb is adapted a glass tube 2.5 mm. in diameter and 1 m. long. To the upper part of this tube a brass collar is cemented to which is attached a vulcanized rubber tube (a) capable of holding from 15 to 20 grms. of powder. The collar (b) contains a diaphram pierced with a very narrow circular hole which will not allow the powder to run into the tube (c) except in the form of a very fine stream like the stream of sand which runs through an hour glass. The bulb (d) opens into a large glass tube, 1.5 to 2 metres long and 25 mm. in diameter, which serves to increase its length, where the pulverulent matters which are held in the smoke are deposited. In order to make the powder run in a continuous stream the caoutchouc tube is agitated by the aid of a small stick fixed to one of its ends as represented in Fig. 2. The combustion of the powder goes on quietly in the bulb when the flow takes place continuously, but interruptions in the flow by no means prevent the success of the experiment. The gaseous products are carried off into the atmosphere. They cannot be collected over either water or mercury, for the pressure which is exerted when the end of the conducting tube is placed under the liquid causes the flame produced by the combustion of the powder in the bulb (d) to rise through the glass tube (c) and explode all the powder contained in the tube (a). The sudden explosion of 15 to 20 grms. of powder is certainly very violent but it is not at all dangerous. The caoutchouc tube in fact offers only a feeble resistance and goes to pieces immediately while the glass tubes, on the contrary, resist very perfectly. Explosions will also occur if the opening in the bulb becomes obstructed during the evolution of the gas. In order to collect easily the gaseous products we have introduced into the extension (e,e) a glass tube which is joined to the bulb tubes (s,s) by means of rubber connecting tubes and the bulb tubes communicate with an aspirator. The bulb tubes (s,s) closed at first by pinch cocks are finally hermetically sealed by fusing their extremities in a lamp flame. We have analyzed separately 1st, the solid residue which is found in the bulb; 2d, the pulverulent deposit which is found in the extension (e,e); 3d, the gas collected in the tubes (s,s).

## A. RESIDUE FROM THE COMBUSTION.

It forms a grayish yellow, semi-fused mass which is soluble in water and leaves a slight residue of carbon. The following is the method of analysis which we pursued:

1. Carbon. This was collected and weighed on a tared filter, 7 grms. of the original substance dissolved in warm water being used. We thus obtained 0.0682 grms. which corresponds to 0.974 per cent.

2. Potassic sulphide. The solution separated by filtration from the carbon was placed in contact with calcined cupric oxide for two days, and agitated from time to time. The liquid, brown at first, finally becomes completely clear. The cupric sulphide, together with the excess of cupric oxide, was collected upon a filter and dissolved in fuming nitric acid. Finally the sulphur, dissolved in the condition of sulphuric acid, was precipitated by the aid of baric nitrate. We obtained 0.1567 grms. of baric sulphate which corresponds to 2.239 per cent. of baric sulphate or to 1.058 per cent. of potassic sulphide, or to 1.077 of potassic hydrate or to 0.9043 per cent. of potassic oxide and to 0.308 per cent. of sulphur.

3. Potassic hyposulphite. For the following researches we have separated the filtrate obtained from the previous analysis into seven portions each of which, consequently, contains 1 grm. of the original substance deprived of its sulphur and carbon.

We treated the potassic hyposulphite with a titrated solution of iodine after having added to the original solution sufficient acetic acid to give a decided acid reaction. Let $a$ be the quantity of iodine contained in one degree of the burette (a= 0.001242 grms.) and $t$ the number of degrees necessary for imparting a blue color to the original solution after the addition of a little starch. We have then the following formula for determining the quantity of hyposulphite.

$$s = a\ t\ \frac{K_2\,S_2\,O_3}{I}$$

The reaction which takes place being as follows

$$2\ I + 2\ K_2\,S_2\,O_3 = 2\ K\ I + K_2\,S_4\,O_6 \quad *$$

We found $t$ = 40.7, a = 0.001242 grms. Then the quantity of hyposulphite = 40.001859 × 40.7 = 0.07566 grms. or 7.566 per cent., corresponding to 3.747 per cent of potassic oxide or to 2.5452 per cent. of sulphur and 8.0434 per cent. of potassic nitrate.

* Potassic tetrathionate.

4. Potassic sulphate. The same quantity of the solution containing 1 grm. of the substance for analysis gave us 0.7582 grms. of baric sulphate which will give, for 100 grms. of the original substance, 56.623 of potassic sulphate corresponding to 10.397 of sulphur, or 30.624 of potassic oxide, or 65.721 of saltpetre.

5. Potassic sulphocyanate. Small quantities of this substance can be readily treated by calorimetric processes. For this purpose we prepared a solution containing in each degree of the burette 0.0004894 grms. of potassic sulphocyanate. As the coloring liquid we used ferric chloride, conveniently diluted and acidified by hydrochloric acid. The quantity of iron which it contained was not ascertained. We took two equal volumes of it which we poured into two similar cylindrical vessels placed in the same position. To one of these we added the liquid containing the sulphocyanate to be tested, in the other we poured the normal solution of the sulphocyanate until the two liquids presented exactly the same color. At the same time we took the precaution to add water to the second vessel in order that the two liquids should be equally diluted. Let $a$ be the quantity, by weight, of potassic sulphocyanate contained in one degree of the burette, and $t$ the number of degrees which are required to render the tint of the liquid identical in the two glasses, we should have for the quantity of sulphocyanate

$$s = a\ t,$$

$a$ being equal to 0.0004894 one would have by this method of treating the sulphocyanate at least 0.0005 grms. We found $t = 17.5$ which gives for 100 of the original substance 0.8564 of sulphocyanate, corresponding to 0.4145 of potassic oxide, or 0.2815 of sulphur, or 0.8896 of potassic nitrate.

6. Treatment of the ammonia. The ammonia is determined by the aid of a titrated solution of hydrochloric acid. The quantity of hydrochloric acid contained in the normal solution of this acid is first determined by means of a solution of silver. The liquid employed contained in one cubic centimetre 0.002357 grms. of anhydrous acid. Two volumes of this liquid, equal to 23.81 cm$^3$, are taken and one of the two is poured into a bottle which is put into a test glass filled with cold water. The solution containing the ammonia is introduced into a retort (Fig. 3) containing potash free from nitrates and submitted to distillation. The conducting tube leads the steam generated into the bottle $e$ where it condenses, thus carrying off all the ammonia from the original liquid. In order to prevent the absorption of the ammonia in the conducting tube a small vulcanized rubber tube is adapted to the

extremity of the latter. This is closed by a small rod of glass and then slit up a slight distance with a pen knife. This opening allows the vapor to pass out but it becomes hermetically sealed each time that a vacuum is formed inside the tube by cooling. When all the ammonia has passed over, which is determined by the volume of water which has distilled, the bottle (*e*) is allowed to cool and its contents are poured into a test glass. In a similar glass the second measured portion of hydrochloric acid is poured, and it is diluted with water until the volume of the two liquids is the same in both vessels. Equal quantities of litmus solution are added to the two solutions and the acid is treated with a titrated solution of ammonia of such a strength that twenty degrees of the burette are sufficient to neutralize the volume of acid used. Let $a$ be the quantity of acid contained in the volume $t$ which is used, and $t$ be the number of degrees used for neutralizing the acid in the two cases, then the quantity of ammonia which has distilled over corresponds to a quantity of hydrochloric acid equal to

$$\frac{a\,(t_1-t)}{t_1}$$

and the quantity of ammonic carbonate contained in the liquid will be given by the formula

$$X = \frac{(N\,H_4)_2\,C\,O_3}{2\,H\,cl} * \; a \; \frac{t_1-t}{t_1}$$

We obtained equal values for $t$ and $t_1$ which showed that there was no ammonic carbonate in the original solution.

7. Potassic nitrate. Having proved that the original solution contained no ammonia, we took, as in the preceding case, a volume containing one grm. of the original substance, acidulated it slightly with sulphuric acid, and placed a strip of zinc in it. The liquid was kept cool and sulphuric acid was added to it from time to time to such a degree that the evolution of gas went on slowly. The potassic nitrate was thus converted into ammonia. Potassic hydrate was then added in sufficient quantity to redissolve all the oxide of zinc precipitated and the ammonia was distilled as in the preceding case. Preserving the same notation the potassic nitrate is determined by the aid of the formula

$$X = \frac{K\,N\,O_3}{H\,cl} \; a \; \frac{t_1-t}{t_1}$$

* Bunsen referred to the ammonic sesqui carbonate but the existence of this salt is not now recognized.

We found $a = 0.05612$ grms., $t_1 = 27$, $t = 18$ from which we deduce $x = 0.05185$ grms.

8. Potassic carbonate. A volume of the original liquid which contains 1 grm. of the residue is taken and the potassic carbonate is precipitated by the aid of a solution of manganous chloride, which has been previously fused. The precipitate is filtered off, washed, and then, together with the filter paper, introduced into a proper apparatus for treating the carbon dioxide. Dilute sulphuric acid is added and it is boiled for sometime. The carbon dioxide, determined by the loss of weight of the apparatus, weighed 0.0860 grms. which corresponds to 27.016 per cent. of potassic carbonate or to 2.3452 of carbon, to 18.417 of potassic oxide and 39.525 of potassic nitrate.

9. Potassic hydrate. By precipitating again the manganous oxide dissolved in the displacing apparatus (8), by the aid of sodic carbonate, we obtained 0.1654 grms. of $Mn_3 O_4$. As a molecule of $Mn_3 O_4$ corresponds to three molecules of manganous carbonate, for 0.0860 grms. of carbon dioxide we should have 0.1495 grms. of $Mn_3 O_4$. On deducting this number from 0.1654 grms. which represent the total weight of the manganoso-manganic oxide precipitated, there remain 0.0159 grms. This amount was not precipitated as manganous carbonate but in the condition of manganous hydrate on account of the presence of the potassic hydrate. But, as $Mn_3 O_4$ corresponds to three $Mn O$ and as for this quantity of manganous oxide six molecules of potassic hydrate are necessary, 0.0159* grms. of $Mn_3 O_4$ correspond to 2.339 grms. of potassic hydrate. Again in the determination of the potassic sulphide we saw that this was transformed into potassic hydrate which is evidently so much to be deducted from the quantity which we have found.

| | |
|---|---|
| Total quantity of potassic hydrate in 100 parts | 2.339 |
| Quantity corresponding to potassic sulphide in 100 parts | 1.077 |
| Remainder | 1.262 |

which is equivalent to 2.274 of potassic nitrate or to 1.0596 of potassic oxide.

10. Determination of the total potassic oxide in the residue. A volume of the liquid, containing 1 grm. of the residue, after having been treated with sulphuric acid, dried and ignited, gave 1.0447

* There is an error here as .0159 grms. of $Mn_3 O_4$ correspond to .02339 grms. of $K H O$. As the value 2.339 is repeatedly used it is probable that the quantity of $Mn_3 O_4$ obtained is misstated.—Tr.

grms. of potassic sulphate corresponding to 56.497 per cent. of potassic oxide.

Summing up the results of these different analyses we have for the composition of the residue in per cents

| | |
|---|---|
| Potassic sulphate | 56.62 |
| " carbonate | 27.02 |
| " hyposulphite | 7.57 |
| " sulphide | 1.06 |
| " hydrate | 1.26 |
| " sulphocyanate | 0.86 |
| " nitrate | 5.19 |
| Carbon | 0.97 |
| Ammonic carbonate | 0.00 |
| Sulphur | 0.00 |

The proportion of potassic oxide contained in the different salts which compose the residue is 56.88; the proportion determined directly in analysis 10 is 56.50; the difference is only 0.38.

The residue from the combustion consists then chiefly of potassic sulphate and carbonate and not of potassic sulphide, as is stated in most of the treatises on artillery and chemistry, this substance reaching scarcely one per cent.

## B. PULVERULENT SUBSTANCES IN THE STATE OF SMOKE.

We have proceeded as follows for analyzing the pulverulent deposit held by the gas in the state of smoke and which was deposited in the long tube (e e) towards its open end. This matter formed a gray adherent coating and smelled strongly of ammonia. We dissolved it immediately in water, then separated the suspended charcoal by filtration and then divided the liquid into (eleven) equal portions which we employed separately for the following treatment.

1. Carbon. The carbon contained in the whole liquid weighed 0.08526 grms, and was free from sulphur. One part of the solution or 1-11 of the total mass contained then 0.00775 grms. carbon.

2. Potassic sulphide. The solution did not blacken paper which had been dipped in plumbic acetate and hence it did not contain any potassic sulphide.

3. Potassic hyposulphite. One of the portions of the solution required 11 degrees of the burette, containing a titrated solution of iodine, which corresponds to 0.02045 grms. of hyposulphite.

4. Potassic sulphate. One of the portions of the solution gave 0.3650 grms. of basic sulphate, corresponding to 0.2726 grms. of potassic sulphate.

5. Potassic sulphocyanate. One portion of the solution required 4.7 degrees of the normal solution which corresponds to 0.0023 grms. of sulphocyanate.

6. Ammonia. Two volumes of the solution gave us $t_1 = 27.0$, $t = 23.9$, $a = 0.05612$, which corresponds to 0.0004373 grms. of ammonic sesquicarbonate or 0.0002445 grms. of carbon dioxide for one part of the solution.

7. Potassic nitrate. One portion of the solution gave $t_1 = 27$, $t = 25.2$, $a = 0.05612$ which corresponds to 0.010374 grms. of potassic nitrate.

8. Potassic carbonate. Two portions of the solution gave us 0.0629 grms. of carbonic anhydride. If we subtract the carbonic anhydride of the ammonic carbonate found in experiment (6) we get for one portion of the solution 0.09803 grms. of potassic carbonate.

9. Potassic hydrate. Two volumes of the solution gave us 0.1169 grms. of manganous oxide which corresponds to 0.05845 grms. $Mn^3 O_4$ for one portion of the solution. If we subtract from this the quantity of $Mn_3 O_4$ (0.05466 grms.) which corresponds to the 0.03145 grms. of carbonic anhydride found in experiment (8), there remains 0.00379grms. of $Mn_3 O_4$ corresponding to 0.00556 grms. of potassic hydrate.

As a result of these analyses we find one portion of the solution to contain:

| | |
|---|---|
| Potassic sulphate | 0.27258 grms. |
| " carbonate | 0.09803 |
| " hyposulphite | 0.02045 |
| " sulphide | 0.00000 |
| " hydrate | 0.00556 |
| " sulphocyanate | 0.00230 |
| " nitrate | 0.01037 |
| Ammonic sesquicarbonate | 0.00044 |
| Carbon | 0.00775 |
| Sulphur | 0.00000 |
| | 0.41748 |

One hundred parts of the solid substance which was dissolved contain then:

| | | |
|---|---|---|
| Potassic | sulphate | 65.29 |
| " | carbonate | 23.48 |
| " | hyposulphite | 4.90 |
| " | sulphide | 0.00 |
| " | hydrate | 1.33 |
| " | sulphocyanate | 0.55 |
| " | nitrate | 2.48 |
| Ammonic sesquicarbonate | | 0.11 |
| Carbon | | 1.86 |
| Sulphur | | 0.00 |
| | | 100.00 |

In order to control these results we have treated a volume of the solution with sulphuric acid and we have thus converted all of the salts of potassium into sulphate. We have thus found 0.4286 grms. of $K_2 SO_4$; according to the preceding analysis we should have obtained 0.4345 grms. The accordance of these two numbers confirm the accuracy of the analysis. On comparing the results of this analysis with those which the analysis of the residue gave we arrive at the following conclusions:

1. The pulverulent matters which form the smoke have an analogous composition to those of the solid residue.

2. The principal difference consists in this, that the combustion of the sulphur and carbon is much more complete and that instead of finding a small quantity of potassic sulphide we have found notable traces of ammonic sesquicarbonate.

## C. ANALYSIS OF THE GASES.

In order to resolve the third question, that is to say, to determine the nature of the gases which result from the combustion, we have employed the apparatus before described (Fig. 2, pl. I). On sucking with the mouth at the end of the tube *ff* the gases contained in the tube *e e*, which come from the burning of the powder we find that their taste is very nearly that of pure carbonic anhydride. This is verified by the fact that the nose does not detect the least odor of cyanogen, of sulphurous anhydride or of nitric oxide, but there are some barely recognizable traces of hydrosulphuric acid. Mixed with air it does not give any trace of reddish vapors. As the presence of even a few thousandth parts of cyanogen, sulphurous anhydride and nitric oxide

can be detected by the odor and taste we can conclude that these gases are not contained in the mixture to be analyzed.

We have found, on the contrary, carbonic anhydride, hydro-sulphuric acid, traces of oxygen, of carbon protoxide, hydrogen, nitrogen and of nitrous oxide. The following are the methods which were employed in the analysis of the mixture.

The carbonic anhydride is absorbed by potassic hydrate and the hydro sulphuric acid and oxygen by potassic pyrogallate. The remainder of the gas is then introduced into a eudiometer with an excess of oxygen and of detonating gas. After the passage of the spark the excess of oxygen is ascertained by mixing it with hydrogen and detonating again.

Let us designate the volumes of the different gases which exist in the mixture as follows.

| | | | |
|---|---|---|---|
| Carbonic anhydride | $c$ | Hydrogen | $h$ |
| Hydrosulphuric acid | $s$ | Nitrogen | $n$ |
| Oxygen | $o$ | Nitric oxide | $n^1$ |
| Carbon protoxide | $c^1$ | | |

Let $A^0$ be the volume of gas first submitted to analysis,

$$A^0 = c + s + o + c^1 + h + n + n^1$$

$c^1$ $s$ and $o$ are given immediately by absorption.

Let $A^1$ be the volume which remains after the absorption. $A^1 = c^1 + h + n + n^1$.

Let $A^2$ be the fraction of the volume $A^1$ introduced into the eudiometer to such a degree that we have $\frac{A^2}{A^1} = \mathrm{m}$

$$A^2 = m\,c^1 + m\,h + m\,n + m\,n^1$$

Designating by $C$ the volume of carbonic anhydride formed during the combustion and by $D$ the diminution in volume then

$$m\,c^1 = C \qquad m\,h = \frac{2\,D - C}{3}$$

Let O be the volume of oxygen introduced into the eudiometer for determining the combustion of $A^2$ and there will remain after the detonation and the absorption of the carbonic anhydride a volume $\mathrm{O} = \frac{C + D}{3}$ and if $V$ represents the total volume which is obtained of $\mathrm{A}^2 + \mathrm{O}$ we should have

$$m\,n + m\,n^1 = V - O + \frac{C + D}{3}$$

In making the volume $V$ detonate with an excess of hydrogen we ob-

serve a diminution of volume $D'$ which is due to the combination of a part of the hydrogen with the volume $O - \frac{C+D}{3}$ of the oxygen and of the rest with the volume $mn'$ of the nitrous oxide. If from $D'$ we subtract the diminution of volume $3\ O - D - C$ due to the oxygen we would have the volume of the nitrous oxide since one volume of this gas in combining with one volume of hydrogen gives one volume of nitrogen then

$$mn' = D' - 3\ O + D + C$$
$$mn = V - D + 2\ O - \tfrac{2}{3}\,(C + D)$$

Such are the calculations and the operations which have served for the analysis of the mixture of the gases produced by the powder. The numbers which have been obtained are,

1st, Gases absorbed.

| | Volume. | Pressure. | Temp. | Vol at 0° under a pressure of 1 m. |
|---|---|---|---|---|
| Original mixture | 136.2 | 0.7359 | 8°.8 | 97.102 |
| After absorption of $CO_2 + H_2S$ | 69.1 | 0.6760 | 8°.0 | 45.382 |
| " " of O | 68.7 | 0.6738 | 8°.6 | 44.877 |

2d, Determination of the Hydrosulphuric Acid absorbed by the potassic hydrate.

146 divisions of the test glass measured 30 cm³. One division of the graduated burette contained 0.001242 grms. of iodine. We employed for the potassic hydrate 1.8 divisions of the burette. Consequently in the volume 97.102 of the gas, at 0° and under a pressure of 1 metre, the volume of hydrosulphuric acid absorbed with the carbonic anhydride would amount to

$$\frac{146}{30} \times \frac{773}{1.175} \times \frac{112.5}{1588.7} \times 0.76 \times .001242 \times 1.8 = 0.58 \text{ div.}$$

3rd, Eudiometric Analysis.

| | Volume. | Pressure. | Temp. | Vol. at 0° and under a pres. 1 met. |
|---|---|---|---|---|
| Original mixture, | 110.0 | 0.3569 | 10.2 | 37.846 |
| After addition of O. | 150.6 | 0.3974 | 10.3 | 57.674 |
| After introducing the detonating mixture, | 189.0 | 0.4350 | 10.3 | 79.230 |
| After the detonation, | 144.2 | 0.3915 | 9.3 | 54.595 |
| After absorption of the $CO_2$ | 135.7 | 0.3915 | 9.1 | 51.414 |
| After introduction of dry H | 220.4 | 0.4753 | 10.9 | 100.740 |
| After deton'tg (the dry gases) | 125.6 | 0.3917 | 9.0 | 47.629 |

With these given we have calculated the quantities which enter into the formulae given above.

| | |
|---|---|
| $A^0 = 79.102$ | $A^1 = 44.877$ |
| $A^2 = 37.846$ | $C = 3.181$ |
| $D = 3.079$ | $O = 19.828$ |
| $V = 51.414$ | $D^1 = 53.111$ |

On solving the equations, we find

| | |
|---|---|
| $c = 51.140$ | $s = 0.580$ |
| $o = 0.505$ | $c^1 = 3.772$ |
| $h = 1.176$ | $n = 40.063$ |

$$n^1 = -0.134$$

The percentage composition of the gas is then

| | |
|---|---|
| Carbonic anhydride, | 52.67 |
| Nitrogen, | 41.12 |
| Carbon protoxide, | 3.88 |
| Hydrogen, | 1.21 |
| Hydrosulphuric acid, | 0.60 |
| Oxygen, | 0.52 |
| Nitric Oxide, | 0.00 |
| | 100.00 |

What is most noticeable in this result is the existence of free oxygen in the presence of a combustible gas. We cannot believe that this points to a fault in the analytical method employed, for its known accuracy and the care which we have taken in applying it will not allow us to suppose that such an error could be possible. We account for this fact, on the contrary, by supposing that, after the combustion of the sulphur and charcoal, the residue of the powder, dispersed in the state of smoke, still contains some saltpetre and that probably, while cooling, this evolves small quantities of oxygen, but the temperature is not sufficiently high to cause the burning of these gases when mixed with a very considerable volume of other incombustible gases.

If the powder in burning is converted, as the old theory teaches, into potassic sulphide, nitrogen and carbonic anhydride, these last two gases should be present in the proportion of 1 to 3. Our examination shows that, on the contrary, this proportion does not reach 1 to 1.5. Then the combustion of the powder ought to take place in a different manner from that which the theory accepted up to the present day supposes.

## CHAPTER IV.

### Relations between the Residue, the Substances which constitute the Smoke, and the Gaseous Products.

We propose now to answer the fourth question which we have propounded. What quantities of solid residue and of smoke on the one hand and how much gas on the other, can be obtained from a given weight of powder?

In order to solve this problem we have analyzed the mixture of residue and deposit which was produced by the quantity of powder that gave, in burning, the gas previously analyzed.

We began by dissolving an unmeasured portion of the substance to be examined in such a volume of water that the volume of the solution occupied 500 $cm^3$. For each particular determination we took each time 45.474 $cm^3$ measured in a gauged test glass. The data necessary for the calculation are, when they are not specially indicated, the same as those stated above in the analysis of the residue of the powder.

I. Carbon and sulphur. The 500 $cm^3$ left a residue, consisting of carbon, sulphur and an incombustible residue, the whole weighing 0.2141 grms. 0.1758 grms. of this deposit gave 0.1749 grms. of baric sulphate, which gives by a proportion 0.0292 grms. as the weight of the sulphur contained in the 0.2141 grms. The deposit treated with nitric acid and ignited in an open crucible left an incombustible residue which weighed 0.0248 grms. For the volume of 45.475 $cm^3$ of the solution used in the following investigation we would have

| | |
|---|---|
| Carbon, | 0.014561 grms. |
| Sulphur, | 0.002656 " |
| Residue, | 0.002256 " |

II. Potassic sulphide. The solution (500 $cm^3$) treated as before with cupric oxide yielded a precipitate of 0.9902 grms. of baric sulphate corresponding to 0.46787 grms. of potassic sulphide or to 0.1358 grms. of sulphur, which would give for the volume of 45.475 $cm^3$ 0.04255 grms. of potassic sulphide.

III. Potassic hyposulphite. One gauged volume required 35.1 divisions of the graduated burette which corresponds to 0.06525 grms. of potassic hyposulphite.

IV. Potassic sulphate. One measured volume gave 1.131 grms. of baric sulphate, corresponding to 0.84463 grms. of potassic sulphate.

V. Potassic sulphocyanate. A measured volume of the solution

required 12.5 divisions of the burette corresponding to 0.006105 grms. of potassic sulphocyanate.

VI. Ammonia. A measured volume gave $a = 0.06688$, $t^1=46.6$, $t=17.3$. This corresponds to 0.01645 grms. of Ammonia, or to 0.05709 grms. of $2(NH_4)_2O, 3CO_2$.

VII. Potassic nitrate. We first determine the quantity of ammonia contained in a quantity of potassic hydrate equal to that which is required for treating the solution. We obtained $a=0.05612$, $t^1=27$, $t=26.4$. The quantity of ammonia corresponding is equivalent to 0.0034578 grms. of potassic nitrate, a quantity which it is necessary to subtract from the total quantity of potassic nitrate found in the solution. We found for the volume of solution employed $a=0,05612$, $t^1=46.6$, $t^1=23.3$, numbers which correspond to 0.077808 grms. of potassic nitrate, and, deducting the weight .003458 grms. we see that the solution contains 0.07435 grms. of potassic nitrate.

VIII. Potassic carbonate and potassic hydrate. With the volume employed we obtained 0.1124 grms. of $CO_2$ and 0.2240 grms. of $Mn_3O_4$. From this weight of carbonic anhydride it is necessary to deduct that which belongs to the ammonia sesquicarbonate, which gives us 0.3531 grms. of potassic carbonate. In this weight of 0.2240 grms. of $Mn_3O_4$ 0.19539 grms. belong to the potassic carbonate. It follows then that 0.0286 grms. of the $Mn_3O_4$ corresponds to 0.03515 grms. of potassic hydrate. But the potassic sulphide has furnished 0.03635 grms. of potassic hydrate. We may then conclude that there is no potassic hydrate in the substance analyzed.

One volume of the solution (45.475 $cm^3$) contains then:

| | | |
|---|---|---|
| Potassic sulphate, | 0.84463 = | 0.45676 of potassic oxide. |
| " carbonate, | 0.25279 | 0.17233 |
| " hyposulphite, | 0.06525 | 0.03232 |
| " sulphide, | 0.04255 | 0.03637 |
| " hydrate, | 0.00000 | 0.00000 |
| " sulphocyanate, | 0.00611 | 0.00296 |
| " nitrate, | 0.07435 | 0.03464 |
| | | 0.73538 |
| Carbon, | 0.01456 | |
| Sulphur, | 0.00266 | |
| Ammonic sesquicarbon'te | 0.05709 | |
| | 1.35999 | |

The same volume gave 1.380 grms. of potassic sulphate corresponding to 0.7463 grms. of potassic oxide, a number which agrees with that which we have deduced from the previous analysis as closely as can be desired.

The powder employed and the products of its combustion have then the following composition.

| A. Powder. | | | B. Solid Products. | | C. Gases. | |
|---|---|---|---|---|---|---|
| Saltpetre, | | 78.99 | Potassic sulphate, | 62.10 | Carbonic anhydride, | 52.67 |
| Sulphur, | | 9.84 | " carbonate, | 18.58 | Nitrogen, | 41.12 |
| Charcoal, | Carbon, | 7.69 | " hyposulphite, | 4.80 | Carbonic protoxide, | 3.88 |
| | Hydrogen, | 0.41 | " sulphide, | 3.13 | Hydrogen, | 1.21 |
| | Oxygen, | 3.07 | " sulphocyanate, | 0.45 | Hydrosulphuric acid, | 0.60 |
| | | | " nitrate, | 5.47 | | |
| | | 100.00 | Charcoal, | 1.07 | Oxygen, | 0.52 |
| | | | Sulphur, | 0.20 | Nitric oxide, | 0.00 |
| | | | Ammonic sesquicarbonate, | 4.20 | | 100.00 |
| | | | | 100.00 | | |

All of the potassium in the powder ought to be found in the solid residue. We should be able then by the aid of analyses A and B to calculate the weight of the residue which corresponds to 1 grm. of powder. This weight of powder contains then, from analysis A, 0.3055 grms. of potassium; the weight of residue which contains the same quantity is 0.6806 grms.

This weight of residue contains a certain weight of nitrogen easy to calculate; on deducting it from the total weight of nitrogen contained in one grm. of the powder we should have the weight of nitrogen contained in the gas produced by the combustion of one grm. of powder. The weight of gas corresponding to this weight of nitrogen is, according to analysis C, 0.3138 grms. We should have then for the products of the combustion of one gram of powder;

| | | | | | | |
|---|---|---|---|---|---|---|
| One gram of powder. | Saltpetre, | 0.7899 | Give on burning. | Solid residue, 0.6806 grms. | $K_2SO_4$ | 0.4227 grms. |
| | Sulphur, | 0.0984 | | | $K_2CO_3$ | 0.1264 |
| | Charcoal, | C. 0.0769 | | | $K_2S_2O_3$ | 0.0327 |
| | | H. 0.0041 | | | $K_2S$ | 0.0213 |
| | | O. 0.0307 | | | $KCNS$ | 0.0030 |
| | | | | | $KNO_3$ | 0.0372 |
| | | | | | C | 0.0073 |
| | | | | | S | 0.0014 |
| | | | | | $2(NH_4)_2O, 3CO_2$ | 0.0286 |
| | | | | Gas, 0.3138 grms. | N | 79.40 cm$^3$ |
| | | | | | $CO_2$ | 101.71 |
| | | | | | CO | 7.49 |
| | | | | | H | 2.34 |
| | | | | | $H_2S$ | 1.16 |
| | | | | | O | 1.00 |
| | | | | | | 193.10 |

In the analyses we have usually compared the total weight employed with the sum of the different products obtained as a check. This check is impossible here since we have operated upon an undetermined quan-

tity of the solid residue. We can however use another species of check. The weight of potassium, nitrogen, sulphur, carbon and oxygen contained in one grm. of the powder ought to be entirely found in the products of the decomposition. We found thus

| | | |
|---|---|---|
| Powder before the combustion. | K | 0.3050 |
| | N | 0.1096 |
| | S | 0.0984 |
| | C | 0.0769 |
| | O | 0.4057 |
| Weight of the elements after the combustion. | K | 0.3050 |
| | N | 0.1096 |
| | S | 0.0989 |
| | C | 0.0780 |
| | O | 0.3936 |

The weights of potassium and of nitrogen are precisely the same in both cases, which shows that the preceding calculation has been made without error. The slight difference which exists between the weight of sulphur, carbon and oxygen demonstrates the accuracy of the method pursued.

We see by the preceding table that one gram of powder, in burning, produces 193.1cm$^3$ of gas. The theory adopted up to the present time requires 330.9cm$^3$, or nearly three times as much.

## CHAPTER V.

### Temperature of the Flame.

Having completed our investigations into the nature of the products of the decomposition of the powder during its combustion we come now to consider the fifth question that we proposed to ourselves at the commencement of this work, viz., the determination of the temperature of the flame. This determination made we shall be in a position to estimate the theoretical value of the work produced during the combustion of the powder. It is important to first define the nature of the flame which the powder produces. Imagine that 1 grm. of powder be inflamed at once throughout all its mass, it will thus produce c units of heat, which will serve to raise the products of combustion to the temperature $\frac{c}{s}$, $s$ being the specific heat of the constituents. This temperature $\frac{c}{s}$ is evidently determined by the aid of the thermometric unit which was adopted in selecting the unit of quantity for heat. But in practice the temper-

ature of the flame diminishes constantly through radiation and conduction, and, as it does not remain equal to $\frac{c}{s}$ only during a very short period, it is impossible to measure it by the ordinary thermometric methods. The combustion of a mass of gunpowder takes place under similar conditions. In this case, it is true, a nearly constant temperature equal to $\frac{c}{s}$ exists but only in the very thin layer where the combustion is going on and the heat produced is dissipated towards the point of the flame by conduction and radiation. In order to obtain the true temperature of the flame produced by the combustion of the powder and to avoid the influence of exterior circumstances $c$ and $s$ should be determined separately.

We have employed the following apparatus (Fig.4) for determining $c$.

A is a brass tube filled with a known weight of fine powder firmly packed. In the mouth $a$ of this tube, which is slightly widened, a small neck of glass $b$ is cemented, to the surface of which two platinum wires $c$ $c$ are fixed and joined to one another by a very fine platinum wire which touches the powder. The small apparatus A is placed in the glass tube B, which is closed at the bottom and open at the top and the whole is finally placed at the bottom of the large tube C in which lateral openings $d$ $d$ are pierced for the two wires. When the two wires $c$ $c$ have been passed through these openings they are closed by the aid of the lamp, and the top of the tube $e$ is also closed. The tube C can be kept vertical by the aid of an appendage which has been blown on the bottom and which penetrates into a cork E; and it is placed in a larger jacket D whose walls are made of very thin brass. In this species of calorimeter a circular agitator is placed which can be raised or lowered by the aid of the very fine wires $g$ $g$. The weight of the powder and of the glass, brass and platinum, which enter into the construction of this apparatus, having been determined it is filled with a known weight of cold water, placed in a case of wood and deposited in a place where the temperature remains nearly constant. There it remains until all of the parts have attained nearly the same temperature.

The quantity of heat furnished by the powder is determined by observing at different moments the temperature of the bath by the aid of a thermometer, placed in a small appendage on the side, which reads to the hundredths of degrees.

We begin by observing the rise of the thermometer before the pow-

der is lighted. Then note the moment when the powder is ignited by the aid of the electric current, then when the thermometer attains its maximum temperature, and, finally, follow its descent during some time. Throughout the duration of the observations be careful to agitate the water in the calorimeter. The following are the numbers obtained in one determination made with the greatest care.

| | Time. | Temperature observed. |
|---|---|---|
| | 0′ | 19.86 |
| | 5′ | 19.83 |
| | 6′ | 19.83 |
| Combustion, | 7′ | |
| Maximum temperature, | 16′ | 21.10 |
| | 26′ | 20.98 |
| | 56′ | 20.60 |

The weights of the different parts being

| | | |
|---|---|---|
| Weight of glass, | 79.14 | grms. |
| brass, | 132.11 | " |
| platinum, | 3.50 | " |
| powder, | 0.712 | " |
| water, | 376.40 | " |

The value, in terms of water, of the different parts of the apparatus, is 404.7 grms. and the heat evolved by the combustion of the powder raised the temperature 1.14°. The heat produced by the powder which we used, that is to say, the rise in temperature which a given weight of powder could produce in the same weight of water is 643.°9.

It is necessary to apply a slight correction to the number that we have found. The combustion takes place in a tube which is in effect hermetically closed and filled with air. The combustible gases produced by the combustion of the powder would burn and produce a small quantity of heat which is foreign to that which is produced by the powder itself. We find from table D that 0.7125 grms. of powder would yield

| | | |
|---|---|---|
| Carbon protoxide, | 0.00669 | grms. |
| Hydrogen, | 0.00014 | " |
| Hydrosulphuric acid, | 0.00128 | " |

We will adopt from Favre and Silbermann the numbers 2403, 34462 and 2741 as representing the heat disengaged by the combustion of these gases. The heat produced under these circumstances would raise the temperature 24.°4 which should be deducted from the 643.°9

obtained above. The actual quantity of heat disengaged by the powder will then be 619.°5. The heat produced by the augmentation of the pressure, which manifests itself in the glass tube after the combustion of the powder, is so slight that it may be neglected.

In calculating the quantity of heat which the powder would produce if all its combustible elements united directly with oxygen we obtain, if we employ the numbers given by Favre and Silbermann, for the combustion of the sulphur, the carbon, and the hydrogen, the number 1039.1 The combustion of the combustible elements of the powder with the oxygen of the saltpetre gives them much less heat than when they combine with free oxygen. This should not surprise us if we consider that the nitrogen contained in the potassic nitrate, and which approaches nearly two thirds of the weight of the combustible elements, ought to absorb a great quautity of heat in its conversion into gas.

We can obtain the temperature of the flame of the powder directly, or rather the temperature which would exist if there were no loss by conduction or radiation, by dividing the number 619.5 by the specific heats of the products of the combustion. In order to obtain this quantity we must multiply the weights of each of the bodies produced by the combustion by its specific heat and add together the products thus found. We have neglected in this sum the potassic hyposulphite, the potassic sulphocyanate and the ammonic sesqui carbonate which are present in very small quantities and the hydrosulphuric acid whose specific heat is unknown. The numbers obtained from these very small quantities would only influence the unit place of the number sought, and can be neglected without appreciable error.

| | Weight. | Specific heat. | Product. |
|---|---|---|---|
| Potassic sulphate, | 0.4554 | 0.1901 | 0.08656 |
| " carbonate, | 0.1362 | 0.2162 | 0.02944 |
| " sulphide, | 0.0229 | 0.1081 | 0.00248 |
| " nitrate, | 0.0401 | 0.2388 | 0.00957 |
| Carbon, | 0.0079 | 0.2411 | 0.00190 |
| Sulphur, | 0.0015 | 0.7026 | 0.00031 |
| Nitrogen, | 0.1075 | 0.2440 | 0.02623 |
| Carbonic anhydride. | 0.2167 | 0.2164 | 0.04692 |
| Carbon protoxide, | 0.0101 | 0.2479 | 0.00251 |
| Hydrogen, | 0.0002 | 3.4046 | 0.00073 |
| Oxygen, | 0.0015 | 0.2182 | 0.00033 |
| | 1.0000 | | 0.20698 |

On dividing 619.5 by .207 we obtain for the temperature of the flame of the powder burning freely in the open air the number 2993° C. If the powder burns in a closed space where the gases are not allowed to expand freely the temperature of the flame will be different. We can find this by dividing the quantity of heat due to the combustion by the specific heat of a constant volume. The following is a table of the calculations.

| | Weights. | Specific heat. | Product. |
|---|---|---|---|
| Potassic sulphate, | 0.4554 | 0.1901 | 0.08656 |
| " carbonate, | 0.1302 | 0.2162 | 0.02944 |
| " sulphide, | 0.0229 | 0.1081 | 0.00248 |
| " nitrate, | 0.0401 | 0.2388 | 0.00957 |
| Carbon, | 0.0079 | 0.2411 | 6.00191 |
| Sulphur, | 0.0015 | 0.2026 | 0.00031 |
| Nitrogen, | 0.1075 | 0.2440 | 0.01846 |
| Carbonic anhydride, | 0.2167 | 0.2164 | 0.03426 |
| Carbon protoxide, | 0.0101 | 0.2479 | 0.00177 |
| Hydrogen, | 0.0002 | 3.4046 | 0.00048 |
| Oxygen, | 3.0015 | 0.2182 | 0.00023 |
| | | | 0.18547 |

The temperature of the flame is then $\frac{619.5}{.18547}=3340°$ in the case when the combustion takes place in a closed vessel and the gases are not able to expand freely.

If the flame of the powder consisted only of the combustible gaseous products, as the calorific capacity of the bodies is constant, as shown by the researches of Regnault and the theoretical work of Clausius, whatever the temperature may be, this value $\frac{c}{s}$ could be determined with great precision. But as the specific heat of the solid bodies augments with the temperature we must consider the numbers 2993° and 3340° as only approximate values, yet they ought not to be very far from the real values considering the slight increase of the specific heat with the temperature. Since $s$ increases with the temperature $\frac{c}{s}$ as found is evidently too large; to this it is necessary to add that the flame is always cooled by radiation and conduction. We can then state with certainty that the numbers 3340 and 2993 form a maximum limit which the temperature of the flame will approach more or less but which it will never attain. With this given we can estimate the

pressure exerted by the powder burning in a space which it completely fills.

## CHAPTER VI.

### WORK PRODUCED BY THE COMBUSTION OF THE POWDER.

Up to the present time it has been generally supposed that the residue held in the vapors during the combustion of powder exerted a strong influence over its mechanical action. Though we cannot deny absolutely that this volatilization takes place, nevertheless at the temperature of the flame of the powder the tension exerted by these vapors does not reach one atmosphere. In order to show this we have fused a small globule of the residue, placed on the end of a platinum wire in a hydrogen flame. The substance was insensibly volatilized in the air but without ebullition, and consequently the tension of its vapors was less than one atmosphere. Now Bunsen,* in his method of measuring the gas, assigns 3259°C as the temperature of the hydrogen flame. We may then neglect completely the pressure of these vapors in the combustion of the powder which is effected between the temperatures of 2993° and 3340° C and calculate thus the maximum tension exerted by the gas produced by the combustion of the powder in a closed space.

Let Gp be the weight of the powder employed and Sp be its gravimetric density; Gr the weight of solid residue and Sr its specific gravity at the temperature of 3340°C; and finally let V be the volume of the gas produced taken at the temperature of 0° and under a pressure equal to one metre, and designating by $t^\circ$ the temperature produced by its combustion in a closed space we should have in order to determine the pressure $p^\circ$ exerted by the gas the formula.

$$p^\circ = \frac{V\,(1+0.00366\,t^\circ)}{\frac{Gp}{Sp} - \frac{Gr}{Sr}}$$

In this equation there is only one quantity, the determination of which presents much difficulty, and this is Sr the specific gravity of the solid residue fused at the temperature of the explosion. We have determined this specific gravity by a method which is not yet known but which one of us has employed for studying the expansion and volatilization of rocks fused at very high temperatures and which renders it independent of the expansion of the vessels which contain these products. The researches made by this method have given us only approximate values, it is true, but sufficiently accurate for the end that we

* Gasometrische Methoden, pg. 254.

have in view. We have found, by this method, for the specific gravity of the solid residue.

| | |
|---|---|
| at 18° | 2.35 |
| at 2808° | 1.52 |

Consequently we have obtained by interpolating to 3340° Sr=1.50. The quantities which enter into the preceding formula are then

| | |
|---|---|
| Gp=1.000 | Sr=1.50 |
| Sp=0.964 | V=193.1 $cm^3$ |
| Gr=0.6806 | $t$=3340° |

And substituting these quantities in the formula we have

$$p=4373.6$$

If in calculating the pressure we take for the specific gravity of the powder residue the number which corresponds to the ordinary temperature (2.35) we have for $p^\circ$ the value 3414.6. In the pressure of 4374 atmospheres found there are consequently about 1000 which are due to the expansion of the residue of the powder on account of the elevation in temperature.

A powder, whose composition is the same as that which we have used, in burning in a cannon behind a projectile, in consequence of the inevitable loss of heat, cannot then exert a greater pressure than 4500 atmospheres, if we admit that the decomposition takes place as we have indicated. If, on the contrary, the decomposition goes on in an essentially different manner when the powder burns freely in a cannon from that which takes place when it burns under strong pressure we could determine it only by collecting the residue formed and the gas developed under those circumstances. If then we discover that under those circumstances the decomposition remains sensibly the same it would be necessary to conclude that some of the estimates of the pressure of powder gases in cannon which are in general acceptance are based upon erroneous principles. Many of the writers upon artillery have stated this pressure as high as 50,000 and some even at 100,000 atmospheres.*

The preceding researches furnish the means for calculating the maximum mechanical effect, or the theoretical work which the powder can produce, when the gas which it furnishes, taken at first under a pressure corresponding to its primitive volume expands in a given space without loss of heat. Let $a_1$, $a_3$, $a_3$, $a_1$, (Fig. 5) be the volume occupied by the weight of powder Gp ; $a_2$, $a_3$, $a_3$, $a_2$, the space occupied

* Piobert Traité d'Artillerie 1847 pg. 322.

by the residue whose weight is Gr, and finally let $a_1$, $a_2$, $a_2$, $a_1$, be the space occupied by the gas at the moment of the combustion. This volume $v_0=\frac{\mathrm{Gp}}{\mathrm{Sp}}-\frac{\mathrm{Gr}}{\mathrm{Sr}}$ serves for calculating the pressure $p$ as we have seen above. Finally let $a$, $a_2$, $a_2$, $a$ be the space which the gas fills when, in consequence of its expansion, the pressure becomes $p$. Assuming $c$, $a_2$, $a_2$, $c$, as the amount of expansion of an infinitely small portion of the gas at the commencement, under the initial pressure of $p_0$, the work done will be $p_0\ d\ v$ and that which will be produced by the complete expansion of the gas.

$$\int_{v^0}^{\infty} p\ d\ v$$

Assuming that we have lost no heat through the walls of the envelope and considering $p_0^1$ as the pressure corresponding to the volume $v_0$* we should have $p=\mathrm{p}^0\left(\frac{\mathrm{v}_0}{v.}\right)$ $k$ being ratio between the specific heats of gases under a constant pressure and under a constant volume. The value of this definite integral becomes in this way $\frac{\mathrm{p}_0\ \mathrm{v}_0}{k-1}$

One gramme of the powder which we have employed gives for $v_0$ the value $\frac{\mathrm{Gp}}{\mathrm{Sp}}-\frac{\mathrm{Gr}}{\mathrm{Sr}}$ $=0.5836\ \mathrm{cm}^3$ and for $p_0$ the value $1029.8\times4373.6$ grms. $k$ was calculated from the composition of the gases and was equal to 1.39. Consequently one kilogram of this powder produces, when decomposing as we have stated, a theoretical work of 67410 kilogrammetres.

* Poisson, Mec. 2 II. p, 647—Clausius, Pogg. Arm. 2,79, Page 396.

# OFFICIAL REPORT OF THE NAVAL ENGAGEMENT BETWEEN THE CHILIAN FLEET AND THE PERUVIAN RAM HUSACAR.—FOUGHT ON THE 8TH OCTOBER, 1879, OFF POINT TETAS.

Translated for and forwarded by

Rear Admiral C. R. P. Rodgers, U. S. N.

Autofagasta, 10th October, 1879.

To the Commanding General.—

Sir:—After my arrival in Mexillones de Chile, formerly Mexillones de Bolivia, which I have reported to you in a letter of to-day, relating the result of my expedition to Arica, I hurried the coaling of the ships of the squadron in order that I might go with them to the south.

This latter step was indicated by the repeated telegrams of the supreme government and those of the Minister-of-War at Autofagasta, which informed me that the Pervuian ships were ravaging the coast of Chile.

I ordered the commanders of the ships of the squadron to leave the port of Mexillones at a late hour of the evening, with the squadron in two divisions. One, formed of the slowest vessels, to keep the land in sight, and look into all bays, coves, and shelters, in the coast, where the enemy might lie in wait. The other, of the swiftest vessels, to keep about twenty or twenty-five miles astern of the first squadron, and further off-shore.

This arrangement of the squadron was not carried into effect, because the commander of the Cochrane was telegraphed by the Minister-of-War to cruise with his ship, the O'Higgins, and the Loa, off Mexillones de Chile during the night and until noon of the next day. The Blanco Encalada, the Covadonga, and the Matias Cousiño, were ordered to cruise during the night near Autofagasta.

In execution of these orders I got underway from Mexillones, with the vessels named, at 10 p. m. of the 7th, and steered to the south, with the land in sight.

At about 3.30 a. m. of the 8th, and when off Point Tetas, the lookout of the Blanco Encalada saw ahead the smoke of two vessels, which appeared to be coming out from the coast to reconnoitre the vessels under my command. These vessels were at about five miles distance.

I gave orders to steer towards the vessels, but they made off as soon as we turned towards them. This made me confident that they

were enemies; and, a little later, the daylight showed me that I had the Huascar and the Union before me.

The chase was determined. In spite of the bad state of the Blanco's boilers, I ordered full speed, and that the ship should be turned directly towards the chase. I easily saw, from the speed of the enemy, that my efforts would be useless, if it did not turn out, as I confidently expected, that the other Chilian vessels would join in the game, and head off the enemy in his flight. In confirmation of my belief, I recollected that the captain of the Cochrane must, at this time, be cruising about twenty miles off Point Angamos.

The enemy fled before us, sometimes inclining towards the west, and sometimes drawing in towards the land, but always steering nearly north. The superior speed of his vessels increased momentarily the distance between us. I continued, however, the pursuit, as the best means of forcing the enemy into action, by encountering the cruisers off Mexillones.

At about 7 A. M., we saw, to the N W., the smoke of two vessels. A few moments after, it was certain that they were our vessels, and that they were chasing the enemy.

The Peruvian vessels, seeing the danger they were in, forced their engines to full speed, and continued their flight to the north, keeping close to the shore; the distance between the enemy's vessels and our ironclads being about sixty-eight hundred yards. The Union, whose speed was the greatest, evidently increasing this distance, the corvette O'Higgins and the steamer Loa left the rest of the Chilian squadron, in her pursuit; the rest of the squadron steering towards the Huascar at full speed.

The Cochrane, forcing her engines to the utmost, succeeded in lessening visibly the distance which separated her from the Peruvian monitor. The latter, making a supreme effort, tried to escape to the north; but our ironclad gained on her, and it was evident that the fight must begin in a few minutes more.

At 8.40 a. m., the Cochrane was at about three thousand metres distance from the Huascar. At 9.15 the latter, still flying, fired the first shot at the Cochrane. Our ironclad did not reply. With a serenity worthy of all praise her commander was not concerned with the fire of the enemy; but continued to advance upon him, in order that the fire of the Cochrane might be more sure and more effective; and the combat, a few moments later, began with a well-sustained fire from both vessels.

The Blanco, meanwhile, advanced towards the enemy. The Huascar after a considerable cannonading with the Cochrane, turned towards the Blanco, and fired some shots at her; these were returned immediately.

There was an interval when the ensign of the Huascar had disappeared, and we thought the fight ended; but the Peruvian flag was almost immediately re-hoisted, and the struggle continued.

As the fight went on, the vessels drew so close together that it was thought that the rams would be used. At one time, the Huascar passed the Blanco at about twenty-five metres distance only, firing her guns, and keeping up a warm discharge from the machine guns in her top. The Cochrane having drawn away from the Huascar, while that ship was closely engaged with the Blanco, presently returned, and, handled with great skill, she placed the enemy between two fires. The enemy then, under the hail of shot from our two ironclads, was obliged to submit.

The Covadonga, near the end of the fight, got within range, and fired upon the enemy. It was evident that the crew of the Peruvian ship were greatly demoralized. Although her engine was going ahead still, as if she still hoped to escape, we could see that some of her men were throwing themselves overboard.

I, therefore, ordered the fire to cease, and ordered the nearest vessels to lower boats to pick up the men in the water. One of the boats from the Blanco, nnder command of the chief-of-staff of the squadron, went on board the Huascar, to take the officers of that ship prisoners; and, a few moments later, this boat returned aboard, bringing the sad information that Captain Grau was dead, killed by a projectile, and that his body had disappeared, and also that two officers who had successively replaced him were dead.

The death of the Peruvian rear-admiral, don Miguel Grau, has been much felt in this squadron, whose chiefs and officers highly honor the patriotism and valor of that great sailor.

I next occupied myself in the transportation of the wounded and prisoners, sent a Chilian crew aboard the prize, and sent her to Mexillones de Chile.

The victory gained near this port has immensely weakened the maritime power of the enemy, and has gained for our republic an excellent vessel of war. Her engine being unhurt this vessel may, after slight repairs, go into battle with our flag flying. Besides this valu-

able acquisition, we have, in our power, twenty-five chiefs and officers prisoners, and more than one hundred enlisted men.

This result has been obtained at a small sacrifice. The Cochrane was struck twice, but was not damaged in any vital part. Her crew, according to the report of her captain, has twelve wounded; of whom one has died, another is gravely hurt, and the rest have slight wounds. The Blanco did not have any loss, and was not damaged in any part.

The conduct of the chiefs, officers, and crews of the vessels of my squadron was excellent. When the destructive effects of our projectiles are seen it will be evident that all were as cool as though we were firing at a target.

In separate communications I forward to you detailed lists of the prisoners, of the number of the dead and wounded, and the reports of the commanding officers of each of the vessels under my command which took part in the battle.

I must add that the O'Higgins and steamer Loa, that went in pursuit of the Union, chased her as far as the river Loa. Seeing the impossibility of overtaking her, it being already late in the day, the chase was abandoned, and our ships steered to the south, reaching Mexillones de Chile at 9 a. m. of the 9th.

Very Respectfully.

Further details of the battle of the 8th of October. Communicated by Captain of Corvette Don Guillermo Peña, second captain of the Blanco Encalada.

At 3.55 a. m. coming out from under Punta Tetas, we endeavored to drive the Husacar north, so that she might meet the Cochrane, O'Higgins, and Loa, off Mexillones. At 9, we saw the smoke of three vessels, and then we felt that our prize was sure. At 9.20 the Huascar fired her two 300-pdrs. at the Cochrane; the latter did not reply, but continued the chase. The Huascar continued her flight to the north. At 9.25 the Cochrane fired with her chase guns with good direction the Huascar replied with two guns. At this time, the Blanco was fifty-five hundred yards off. At 9.30, the action between the Huascar and the Cochrane was fully engaged; the Huascar steering about NNE. At 9.35, one of the Cochrane's shots struck. At 9.38 the Huascar turned her bow towards the Cochrane. At 9.45 the Cochrane put a shell through the Huascar, and at 10, another through her side. At 10.01 another in the same side, and the Huascar turned her bow towards Punta Chacaya. At 10.03, a shell from the Cochrane

struck the Huascar's stern. At 10.04 one struck the side; and at 10.08 another in the same place. At 10.09 the Blanco fired at two hundred yards. At 10.10 the Huascar's flag was hauled down; but 1m. 30s. later, it was rehoisted. At this time the fight was renewed with us very near. At 10.36, we put a shell through the Huascar's stern; and at 10.37 two shots in the side and at the line of flotation. At 10.55 she hauled down her flag, was taken possession of by fifteen sailors and five soldiers, and at 11.30 steered towards Mexillones, using her own engine. She anchored at Mexillones at 3.05 p. m.

II. Communicated by the commander of the Loa, captain of Corvette don Javier Molinas.

6.10 a. m. Saw smoke to the south. Signalled immediately to Cochrane and O'Higgins. Fired the two stern guns. Cochrane and O'Higgins steered towards the shore. Huascar and Union forced towards the shore. Blanco and Covadonga chase from the south. Cochrane and O'Higgins to the north; Loa to the west, steering south.

9.20 a. m. The Huascar fired her two 300 pdrs. at the Cochrane. Shot passed over.

[Then follows a description of the fight, already described by Captain Peña.]

10.57. The Loa and O'Higgins start in pursuit of the Union.—12.15 p. m. The Loa passed the O'Higgins. The chase continues. 2.30. Fired the bow guns. 2.40. Fired the 150 pdr. at the Union. We were going fourteen knots at full speed. 2.45 Loa on the port side of Union. Fired the bow gun. 3.29. Fired the bow gun, and, seeing that the pursuit was useless, ordered half-power.

La Union, although within shot, did not reply to a single one of our shots. She increased her speed to an extraordinary extent.

# In Memoriam.

## Commodore Foxhall A. Parker, U. S. N.

### Vice President of the Naval Institute.

On the 10th June 1879, the Institute lost in the death of its Vice President one who, from the foundation of the society, had ever been a most ardent champion and zealous member. Commodore Parker was chairman of the committee which organized the Institute, a member of the first Executive Committee and President for 1878. He read the first paper before the society and for six years was always ready to forward its interests by earnest work and able literary contributions.

## BOOK NOTICES.

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At a recent meeting of the Executive Committee it was

*Resolved*:—That notices and reviews of professional books may be inserted in the proceedings; but that no American book shall be reviewed unless a copy be sent to the Corresponding Secretary, to be deposited in the Library of the Naval Institute, and that all reviews shall be signed by the reviewer.

C. BELKNAP. *Secretary.*

The Life and Letters of Admiral D. G. Farragut, D. Appleton & Co. The Service, as well as the country at large, is indebted to Mr. Farragut for the excellent life he has given us of his father. The work is almost an autobiography, the greater part of the volume being extracts from the Admiral's journals. The days of pirates, of boarding, and romantic adventure are linked, in the simple narrative of the great sailor, to the stern realities of the late war.

Between the lines one reads of the development of the man, and the Navy from the days of the earlier combats to the latest victories; while a spirit of steadfast devotion to duty, and a knowledge of the exact means to bring about a desired end, show how fixed purpose, and not chance, gained the admiral's commission.

Mr. Farragut deserves great credit for the literary ability displayed in the book and the tact with which he has avoided the temptation of allowing his filial pride to mar the historical value of the biography.

He has let his father tell his own story, and when the author appears it is with an unassuming modesty which shows how deeply he has felt the obligation upon him.

A Text Book of Naval Ordnance and Gunnery, *by A. P. Cooke, Commander, U. S. N. Second Edition.* John Wiley and Sons, New York.

The science of gunnery is so constantly changing that it is almost impossible for a text book on the subject to keep pace with the rapid improvements. The latest edition of "Cooke," however, has embodied in it all the innovations of the past few years. The new processes of making cannon metals, and the recently constructed guns of the United States and Europe have taken the place of the almost obsolete methods and ordnance given in the first edition.

The numerous fine engravings and lucid descriptions of the Siemens-Martin steel, the Lowell Battery, the 8 inch M. L. R., the 100 ton gun, and 80 pdr. rifle are especially deserving of mention, and reflect great credit upon Commander Cooke and his collaborator Lieut. J. C. Soley.

J. W. MILLER.